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CHORIO-EPITHELIOMA OF THE UTERUS

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INCLUDING the experience herewith recorded, my acquaintance with chorio-epithelioma of the uterus is limited to an investigation of 5 cases, 4 of which were studied only pathologically, the material being first seen at necropsy.

In a co-ordinated clinical experience covering a period of 16 years, neither Dr. Watkins nor I encountered a single case of chorio-epithelioma, although we were constantly on the lookout for them. During that time we saw several patients with suspected chorio-epithelioma but it was never possible to confirm the diagnosis. All told, including more recent years, I have seen perhaps 20 patients referred with a provisional diagnosis of this disease. In only a few was there notable suspicion of chorio-epithelioma after the history had been taken and physical examination had been made; and in no instance, except the one hereinafter related, did further study confirm the diagnosis. In passing, it may be well to emphasize that complications of normal pregnancy sometimes arouse suspicion of chorio-epithelioma; several times I have known of a false diagnosis of this dreaded disease, based on microscopic evidence, in cases in which more careful study revealed only retained products of gestation.

An experience such as has just been described is probably unique and I am perhaps unduly skeptical about the real incidence of chorio-epithelioma. Yet I would feel guilty of a serious omission in failing to mention that it is a very uncommon disease. Its frequency is very likely overestimated because the clinical course is unusually rapid and fatal and the pathological picture presented at autopsy leaves a lasting impression. The multicolored, brilliantly hued, hæmorrhagic tumor nodules are so striking that one can scarcely fail to diagnose the condition at autopsy after having once viewed the lesions as encountered in the pelvic and abdominal viscera and in the lungs.

The case herewith reported is presented because the clinical evidence was so clear-cut and because the patient was available for thorough study throughout, including complete necropsy examination.

A nulliparous female patient, aged 28 years, married 4½ years, referred by Dr. C. W. Yarrington, reported with the following history:

Fig. 2. Chorio-epithelioma of the uterus, viewed from behind. The colors are almost perfectly reproduced. Hegar's sign was strongly positive. Note the metastatic nodule in the right broad ligament. The opened uterus contained an egg sized, deep red, somewhat pedunculated, hæmorrhagic tumor mass.

Fig. 4. Chorio-epithelioma. The lungs presented a brilliant picture. The multicolored umbilicated tumor nodules were of rather soft consistency, varied from hickory-nut to walnut size, and on incision revealed dark brown, hæmorrhagic necrotic surfaces. The intervening pulmonary tissue was infiltrated with confluent areas of bronchopneumonia. Red brown, nodular tumor masses were also present on the adjacent diaphragm.

Two years prior to our examination, following a 6 weeks period of nausea and vomiting suggestive of pregnancy, there developed a sudden profuse hæmorrhage necessitating immediate transfer to the hospital. A diagnostic and therapeutic curettage by Dr. Yarrington yielded a double handful of grape-like clusters of tissue, most of the vesicular material having a clear, watery content; a small amount of intervening tissue connected the cystic nodules.

Histological study of the curetted material failed to reveal evidence of malignancy and the further clinical course was uneventful until 18 months later, when a persistent cough and expectoration of blood caused some concern. Shortly thereafter, 3 months prior to her death, the patient missed two menstrual periods but otherwise enjoyed fairly good health, aside from respiratory distress. Two months subsequently (a month prior to death) there developed a paralysis of the external rectus muscle of the right eye. This was followed, in a few days, by the appearance of a lipoma-like, soft, subcutaneous nodule near the sternal end of the right clavicle (Fig. 1).

Examination, September 25, 1930, showed the patient somewhat prostrated and rather pallid, with slight dyspnœa, a hacking cough, and blood stained expectoration. Pelvic examination revealed the lower genital tract normal in all respects. The fundus of the uterus was anterior, one and one-half times normal size and the outline was somewhat irregular, although definite nodules could not be palpated. A tendency to soft consistency of the body of the uterus was noted. *Hegar's sign was strongly positive;* this was so marked that it seemed possible, without notable effort, to saw the uterus into two parts, with the palpating fingers, at the level of the lower uterine segment. Fullness, supposedly ascribable to a large corpus luteum, was present in the region of the right adnexa.

Fig. 1. Patient with chorio-epithelioma. Photograph 10 days before death. Paralysis of external rectus muscle of right eye due to cerebral metastasis. Subcutaneous metastatic nodule in region of right sternoclavicular joint.

Examination of the chest revealed, in the skin over the right sternoclavicular joint, the aforementioned, movable, soft, lipoma-like nodule, the size of a fifty cent piece. Marked dullness was present over the entire chest and coarse râles were heard throughout.

X-ray study by Dr. Case revealed extensive tumorous involvement of both lungs characterized by the presence of numerous small rounded shadows, more or less uniform in size, the nodules varying from 1 to 2 centimeters in diameter.

Diagnosis: This case presented a textbook picture of chorio-epithelioma, exceptional chiefly in the long period of time—more than a year and a half—which elapsed from the passage of the hydatid mole until the appearance of clinical symptoms of malignancy.

Pathological study: In anticipation of a possible early exitus, despite the fact that the patient was ambulatory at the time of our examination, plans were made for an immediate pathological study, in the event of death. The end came suddenly and unexpectedly as a result of pulmonary hæmorrhage.

A complete necropsy examination was made within 3 hours after death, by Drs. Yarrington, George Gardner, and the writer; this included removal and study of the brain by Dr. Hale Haven.

Full appreciation of the appearance of the gross lesions, notably the brilliant color of the tumorous nodules and the adjacent tissues, can best be obtained by reference to the accompanying colored illustration, accurately depicted by Tom Jones as promptly as possible within the hours immediately following the autopsy, before postmortem discoloration had developed.

The uterus, examined with the abdomen open and before removal, was of soft consistency, the body globular, nearly double normal size, brilliantly colored and slightly nodular on its serous surface. Exceeding softness of the lower uterine segment (Hegar's sign) was again noted. The opened organ contained an egg-sized, deep red, somewhat pedunculated, hæmorrhagic tumor mass, not unlike infarcted placental tissue in gross appearance. In the fundus of the uterus were smaller, umbilicated, plum colored, somewhat necrotic hæmorrhagic nodules.

In the right broad ligament was a highly colored, infiltrating, purple nodule approximately the size of the ovary and not unlike an ovary in which there had been an extravasation of blood (Fig. 2).

The cervix of the uterus was unchanged. There were no cervical or vaginal metastases or retrograde vascular metastases.

Some metastases were present in the higher pelvic veins, but most of the venous trunks remained free. Isolated, plum colored, slightly umbilicated nodules were present in both kidneys, notably in the left (Fig. 3). The liver, both on the exposed surface and

on section, revealed hæmorrhagic maroon colored, friable tumor masses, varying from 1 to 3 centimeters in diameter. In cut section of the liver parenchyma these tumors were found to be hæmorrhagic and semi-necrotic and passed over gradually into the surrounding normal tissue.

The right pleural cavity was filled with fresh blood. Acute hæmorrhage had evidently been the immediate cause of death. The lungs, held by firm pleural adhesions, presented a brilliant picture. Detailed description of the appearance of the pulmonary metastases appears superfluous in addition to the illustration presented herewith (Fig. 4). The multicolored umbilicated tumor nodules were of rather soft consistency, varied from hickory-nut to walnut size and on incision revealed dark brown, hæmorrhagic, necrotic surfaces. The intervening pulmonary tissue was infiltrated with confluent areas of bronchopneumonia. Red brown, nodular tumor masses were also present on the adjacent diaphragm. The heart was normal.

Cerebral metastases were present in the right gasserian ganglion, beneath the cortex of the left cerebral hemisphere in the region of the motor area, and in the silent area of the right occipital lobe (Fig. 5).

Histological preparations, as is usual in these cases, revealed chiefly necrotic tissue, blood spaces, and extravasated blood. It was necessary to prepare a great number of blocks of tissue in order to find typical areas of tumor cells. In selected regions were found nests of clear Langhans cells, deeply staining syncytial cells of varied size and in characteristic grouping, also masses of multinucleated large cells which are so characteristic of this growth (Fig. 6).

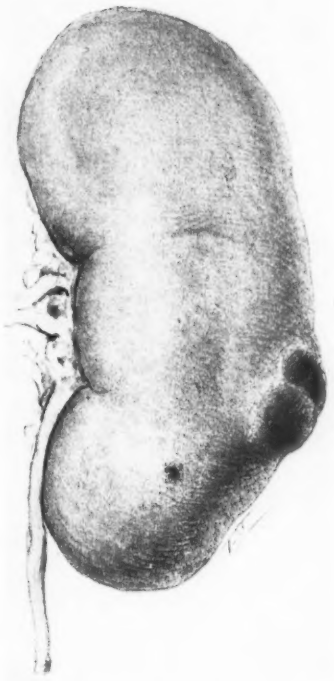

Fig. 3. Chorio-epithelioma. Metastatic nodules in left kidney.

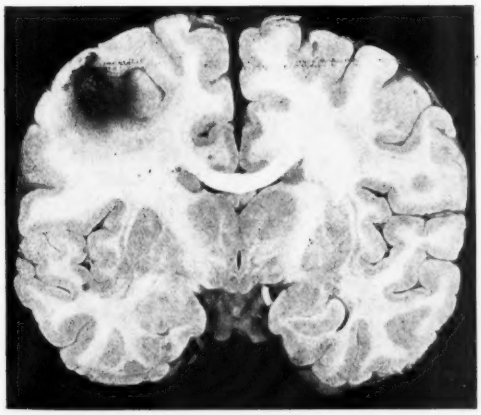

Fig. 5. Chorio-epithelioma. Cerebral metastases were present in the right gasserian ganglion, beneath the cortex of the left cerebral hemisphere in the region of the motor area, and also in the silent area of the occipital lobe on the right.

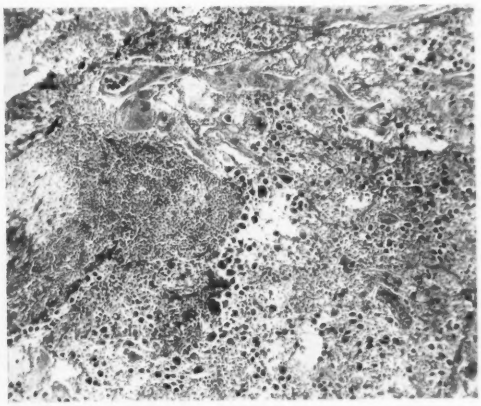

Fig. 6. Chorio-epithelioma. Photomicrograph of pulmonary metastasis revealing lightly staining clear Langhans cells, deeply staining syncytial cells, multinucleated large tumor cells characteristic of this growth, also blood spaces and extravasated blood.

SUMMARY

The incidence of chorio-epithelioma of the uterus has evidently been overestimated. The disease is not only rare but its presence has often escaped clinical diagnosis, so that cases have usually been available for study only after recognition in the pathological laboratory.

The brief report submitted herewith presents a case with a perfect history of chorio-epithelioma in which clinical observation was followed by autopsy and complete pathological study immediately after death. Incident to this study, colored illustrations were made within the hours immediately following the autopsy, before postmortem discoloration had developed, in order to portray, in life-like colors, the appearance of the uterine tumors and the visceral metastases.

A feature of special interest is the presence of an easily elicited positive Hegar's sign, which is evident not only during life, but is confirmed thereafter at autopsy, before the removal of the uterus from the opened abdomen. The fact that Hegar's sign persists in the presence of living chorionic cells, despite prolonged absence of the fetus, is worthy of note.

The appearance of clinical evidence of chorio-epithelioma more than a year and a half after birth of an hydatid mole is also worthy of note. It has been generally assumed that evidence of malignancy may be depended upon to appear at a much earlier date. After passage of a typical mole the patient should evidently be kept under close observation for an indefinite period of time.

IS THERE A CLOSED LYMPHATIC SYSTEM CONNECTING THE THYROID AND THYMUS GLANDS?

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SEVERAL types of evidence indicate that a relationship exists between the thyroid and thymus. The fact that the thymus gland is hypertrophied in exophthalmic goiter has long been known (2). The thymus is said to enlarge with thyroid feeding and it is claimed that thyroidectomy promotes involution of the thymus. Feeding thyroid extract to the pregnant animal is reported to cause an increase in the size of the thymus in the offspring. The increase or decrease in size of the two organs is said to go hand in hand. Sharpey-Schafer believes this could occur only in early life since under ordinary circumstances the thymus is involuting when the thyroid is becoming more active. However, our ideas regarding the time when involution occurs have been greatly modified, largely through the investigations of Hammar (3).

In commenting upon the physiological relationships between these two glands, Sharpey-Schafer says: "in spite of many observations, so little is accurately known regarding the conditions under which they occur (under which the glands undergo regression or enlargement)[1], that it will be wise to reserve judgment as to their mutual relations."

These structures are described as having close connections developmentally and anatomically. The thymus is developed from the caudal aspect of the third and fourth branchial pouches. The main part of the thymus originates according to most authorities from the third pouch, while that coming from the fourth branchial pouch may be found associated with the thyroid. Thymic tissue having this origin is often found embedded in the thyroid and can be recognized by the Hassall's corpuscles and lymphocytes.

Anatomically, the cervical portion of the thymus varies in location considerably and thymic tissue has been described to exist in different cadavers from the base of the skull to the pericardium (11). Thymic tissue is not infrequently found embedded in the thyroid as already stated.

The thymus derives its arterial blood supply from the thyroid vessels, in part, by way of branches from the superior and inferior thyroid arteries as well as from the pericardial arteries. It is also supplied by branches of the internal mammary artery. The veins from the thymus end in the left innominate vein, the thyroid veins, and the internal mammary veins. The lymphatics of the thyroid are described in textbooks of anatomy (7) as leaving the gland cephalomedially to enter some small prelaryngeal nodes, cephalolaterally to go to the deep cervical nodes, and caudally to pretracheal and deep cervical nodes. Among the older investigators, King (5), whose work was published in 1836, wrote: "They (the thyroid lymphatics) pass out from and cover all parts of the surface of the gland; form some junctions; and proceed, for the most part, into neighbouring absorbent glands . . . . The most important novel fact concerning the thyroid gland is doubtless this, that its absorbent vessels carry its peculiar secretion to the great veins of the body."

Caylor, Schlotthauer, and Pemberton (1) have quite recently studied the lymphatic connections of the thyroid in a number of species of animals, and Mahorner, Caylor, Schlotthauer, and Pemberton (6) have made similar studies on the distribution of the thyroid lymphatics in man. Their results are essentially confirmatory of those obtained by previous workers in showing that the thyroid lymphatics pass to nearby lymph nodes whence efferent vessels pass directly or indirectly to the cervical veins. The lymphatics of the thymus are briefly described in most textbooks of anatomy as ending in either anterior mediastinal, tracheobronchial, or sternal lymph nodes.

[1] The words in parentheses are ours.

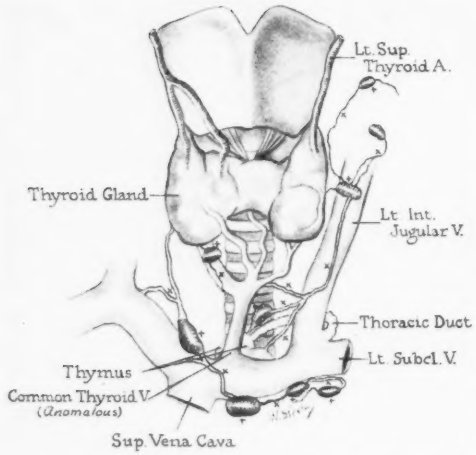

Fig. 1. Dissection showing lymphatics of the thyroid and thymus regions. Human cadaver. Aged 54 years. ×, Lymph vessels; +, lymph nodes.

Williamson (12), and Williamson and Pearse (13) have reported evidence which indicates to them that the thyroid and thymus glands are joined by a special lymph system. This system, they believe, consists in lymph channels which directly join the thyroid and thymus without first passing through lymph nodes en route. These authors state that these special lymphatics leave the thyroid at the hilum of the gland and that many of them can be found passing to the thymus in Piersol's ligament (suspensory ligament).

Such a closed thyrothymic lymph system, if it existed, would truly be unique in the mammalian organism, and we know of nothing to which it might be analogous.

These observations are so entirely at variance to those reported by most investigators (King, Caylor and coworkers, Mahorner and coworkers, etc.) that we thought it would not be without interest to make a detailed study of the lymphatic connections in the thyroid and thymus region.

METHODS

In the present work the results were obtained by two general methods: (a) dissections of human cadavers; (b) by injection of India ink or a modified Gerota's fluid into the thyroid or thymus of human beings and dogs soon after death. The course of the lymphatics was demonstrated distinctly by the fluid as it penetrated into the lymphatics from the thyroid gland. The results of a few of the dissections are given below.

The neck and anterior mediastinal regions were dissected with special care in six adult males and in one male child. Both senior authors performed a part of each of the dissections, one working on the left side, the other on the right side of the neck. A few typical protocols of these dissections are given.

Dissection 2. Adult male, aged 32 years. A considerable amount of lymphadenopathy was found in the neck in this case, more marked on the right than on the left side. On both the right and the left sides lymphatic vessels were found which connected the thyroid with the cervical lymph nodes. A number of lymphatics were found to arise from the ventral and ventrolateral surfaces of the thyroid and these were traced to their termination in the cervical lymph nodes. Careful search for lymphatic vessels was made in the tissue just caudal to the thyroid, known as Piersol's ligament. We were unable to find any lymphatics in this tissue. A considerable number of thin walled empty veins were found to accompany practically every branch of the inferior thyroid artery. These were traced to their termination in either the innominate or the internal mammary veins. Branches of the superior laryngeal, recurrent laryngeal, and sympathetic nerves were found entering the thyroid gland near the hilum.

Dissection 6. Adult male, aged 54 years (Fig. 1). In this body the thymus was comparatively small but was easily distinguished from the lymphatic tissue. Several lymph vessels were observed to arise in the thyroid gland on the right side of the neck. These joined other lymphatic vessels coming from the mediastinum and they eventually emptied into the right jugular trunk. Several other lymphatic vessels were found to arise in the thymus tissue. These were traced to lymph nodes near and below the left innominate vein. From these nodes, vessels were found to enter the right lymphatic duct after passing in front of the superior vena cava. The main right lymph duct was observed to terminate at the junction of the internal jugular with the right subclavian vein. Another lymph duct on this side was found to empty into the right internal jugular vein just before it joined with the right subclavian vein to form the right innominate vein.

On the left side, the thoracic duct was seen to divide into two main branches about 2 inches from its termination and each of the branches emptied separately at the junction of the left internal jugular and the left subclavian veins. One of these branches received tributaries from the thymus directly and also several vessels entered it from the mediastinal

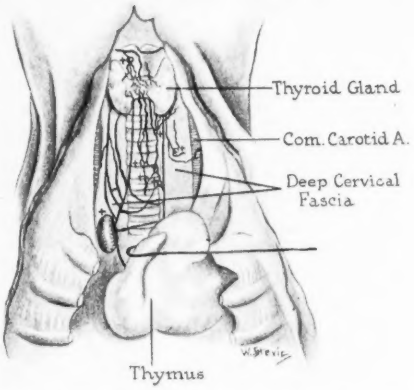

Fig. 2. Dissection of injected lymphatics of thyroid and thymus regions from a baby 5 days old. Black lines, lymph vessels; +, lymph nodes.

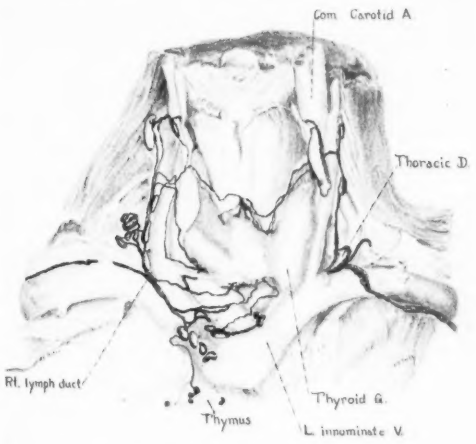

Fig. 3. Dissection of injected lymphatics of the thyroid and thymus regions from a man aged 60 years.

lymph nodes. The other main branch of the thoracic duct received lymphatic tributaries from the thyroid gland which accompanied branches of the inferior thyroid artery. By ordinary inspection these thyroid lymphatics appeared to emerge from the interior of the thyroid. Further careful dissection showed, however, that they arose only from the superficial surface of the gland.

On both sides, lymph vessels were observed which emerged from the superficial surface of the thyroid gland and followed the course of the superior thyroid artery and vein, but their exact termination was not determined.

Dissection 7. Male child about 4 years old. The thymus measured 6.5 by 4.5 by 1 centimeters. Many small lymph vessels could be found leaving the thymus on both sides. Some of these could be traced to the pericardium and to the lymph nodes along the course of the internal mammary arteries. Other lymph vessels arising in the thymus could be traced to the superficial and deep cervical lymph nodes. Vessels from these nodes were followed to their termination in the right lymphatic duct on the right and the thoracic duct on the left side of the neck. Numerous small lymphatic vessels were found to arise from the superficial part of the thyroid.[1] These were traced to the superficial and deep cervical lymph nodes from whence lymphatics could be traced to their termination in the right lymphatic duct and thoracic duct respectively.

In this and all other dissections which we carried out, no direct lymphatic connections could be observed between the thyroid and the thymus.

[1] In several figures Nonidez shows lymphatic vessels of microscopic size within the substance of the thyroid gland of dogs.

The distribution of the lymphatics of this region was very similar in all the cadavers that we dissected. For this reason we do not believe it necessary to present a description of all our dissections as this would be merely a repetition.

INJECTION EXPERIMENTS

Injection of the thyroid gland was carried out in seven human bodies recently dead and unembalmed (1 infant, 1 child, and 5 adults). In all but one of these a modified Gerota's fluid (Prussian blue) was injected into the thyroid on each side. India ink diluted 1:5 was injected into the thyroid of one body. After massaging the gland for a period of from 5 to 15 minutes the course of the lymphatics could be easily traced.

Figure 2 illustrates the lymphatics and the location of lymph nodes in the anterior cervical region in an infant 5 days of age. Similar results were obtained on injection of the dye (Gerota's fluid) into adults and a summary of the findings will suffice to indicate what was found in all these experiments.

After the injections, lymph vessels could be seen extending upward, downward, and laterally from the thyroid. Those passing downward could be seen to enter small lymph nodes on the ventral and ventrolateral surfaces of

the trachea or they terminated in lymph nodes just cephalad to the innominate veins. The dye penetrated beyond these nodes in several instances, but in only one case did it reach the thymus (Fig. 3).

The lymph vessels which passed upward from the thyroid were not traced in all bodies, but in those in which they were followed the vessels were found to empty into superficial cervical nodes.

Laterally lymphatic channels were traced to nodes situated about the carotid arteries and internal jugular veins.

The results obtained by injection of modified Gerota's fluid serve to confirm those secured by careful dissection and they support the view that there are no direct lymphatic connections between the thyroid and thymus, although at times, lymphatic vessels from the two glands may be found to enter the same lymph node (Fig. 2). Further evidence against a direct lymphatic connection between these structures was derived from another experiment in which we injected one-half cubic centimeter of a dilution of India ink into the thyroid of a male child, about 3½ years old, who had recently died. After massaging the thyroid gland for about 10 minutes, there was no change in the appearance of the thymus and histological sections of the latter failed to reveal evidence that carbon particles had passed into it.

To determine whether similar conditions to those found in man obtain in another species we injected modified Gerota's fluid into the thyroid or thymus of dogs under ether anæsthesia or into these glands of dogs recently killed. Six dogs were injected with modified Gerota's fluid (thymus of one animal which had recently died; thyroid of another recently killed; thyroid of four others injected while under ether anæsthesia).

In the animal in which the thymus was injected the fluid did not penetrate the entire gland nor did it pass to any lymph nodes even after massaging for about 10 minutes. In four animals the Gerota's fluid was injected into the living animals. In all cases dissection of the cervical region 20 to 30 minutes after injection revealed that the colored fluid had passed down in the lymphatics for a distance of 1½ to 2 inches to enter lymph nodes caudal to the thyroid. In two of the animals, lymphatics could be traced laterally to enter cervical lymph nodes; in the 2 others the fluid could be seen in lymph channels which passed cephalad for about an inch to enter several small cervical lymph nodes. There was no evidence that the fluid passed into the thymus in any of these animals when it was injected into the thyroid. In the one animal which was injected after death, the results were similar to those already described.

Two other experiments were performed on young puppies in which a suspension of India ink was injected into the thyroid glands, with the animals under ether anæsthesia. Three hours later the animals were killed with ether and the thyroid, thymus, and intervening tissue were removed intact. These tissues were sectioned to determine whether the ink had passed from the thyroid to the thymus. In neither animal was there any evidence of carbon particles in the thymus on histologic examination of this tissue. This is further evidence that no direct lymphatic connections exist between these two glands.

DISCUSSION

While there is much evidence gained from physiological experimentation and pathological cases to show that the thyroid and thymus glands are related, the exact nature of this relationship remains obscure. Williamson and Williamson and Pearse, as previously noted, have reported observations which indicate to them that these two glands are connected anatomically through a closed lymphatic system. These investigators present arguments based upon embryological and pathological studies which they believe add support to their anatomical observations in favor of there being a closed thyrothymic lymph system.

They believe that the special lymph vessels of the thyrothymic lymph system emerge from the thyroid at the hilum at the point at which the inferior thyroid artery enters. From here these lymphatics are described as following the arteries instead of the veins. They found lymphæ comites accompanying the veins and traced them into the nearest lymph glands. The special thyrothymic ves-

sels are described as running below the thyroid in the thyrothymic ligament (Piersol's ligament) or they run as discrete vessels ending in the thymus without passing through lymph glands.

Embryologically, they believe, the thyroid-gill lymph system of fishes has some analogies with the thyroid lymph sac in the human embryo. The thyroid, thymus, and connecting lymphatics are said to lie in a specific fascial plane and it is believed that the lymph sac in fish occupies precisely this plane. "We may infer, therefore, from comparative anatomy and embryology, that the thyrothymic lymph system of mammals is derived from a thyroid-gill lymph system in fish" (13).

Our studies on the connections of the lymphatics of the thyroid and thymus have been limited to observations on the relations of these structures in two species of mammals, human beings and dogs. The present investigation has been purely anatomical in character and hence the discussion of our findings will be limited to this phase of the subject. The results reported lend little support to the contention of Williamson and Pearse favoring a closed lymph system between these two glands. We have shown, both by careful dissection and by injection experiments, that the lymphatics from the thyroid, in common with lymph vessels from other organs of this region, pass to lymph nodes in either the deep cervical group or to nodes in the superior mediastinum. We have noted that, occasionally, the lymph vessels from the thyroid and thymus may enter the same lymph node. In one of the injection experiments in man Gerota's fluid injected into the thyroid could be traced into the thymus after it had passed into and through a lymph node.

Our observations are in essential agreement with those made by Caylor, Schlotthauer, and Pemberton (1) on dogs, and by Mahorner, Caylor, Schlotthauer, and Pemberton (6) on human beings. These investigators studied the lymphatic connections in several species of animals (dogs, swine, rabbits, guinea-pigs, calves, a colt, and man). They found that the lymph drainage system from the thyroid of dogs could be divided into three main groups. In the first group the lymph vessels from the posterior pole passed to a series of lymph nodes extending along the ventral surface of the trachea and, from these, efferent vessels passed into the thymus and mediastinum. In this group of animals India ink injected into the thyroid was usually visible in the thymic tissue on histological section. In a second group of dogs, the lymphatics from the posterior pole of the thyroid emptied directly into the jugular trunk. In this group, no India ink was found in the thymus. In a third group of dogs, the lymph vessels coming from the posterior pole of the thyroid did not pass through any lymph nodes before entering the general circulation.

A method similar to that used in the study of the lymph connections in animals was followed by Mahorner, Caylor, Schlotthauer, and Pemberton in the investigation of the thyroid lymph connections in man. They found that the lymph vessels leave the human thyroid at three areas (at the superior and inferior poles and the middle of each lateral lobe).

Vessels from the superior pole were found to follow the course of the superior thyroid artery at first and later they turned backward and downward to end in lymph nodes of the deep cervical group. Lymph vessels leaving the inferior pole of the gland passed downward to end in the lymph nodes anterior or lateral to the trachea. In only one instance were they able to trace a lymphatic from the thyroid to the thymus. In this case the connection was made only after passing through a lymph node in the region above the left innominate vein.

It would seem from the results of Mahorner and coworkers that anything resembling a closed lymph system between these two glands is unusual. Their work, of which ours is essentially confirmatory, indicates that there may be a considerable individual as well as species difference in the course taken by the lymphatics leaving the thyroid. Caylor and coworkers found a much closer association between the thyroid and thymus lymphatics in swine than in either human beings or dogs.

Williamson and Pearse have proposed a theory to explain certain phases of thyroid disease which is based on their anatomical and

pathological studies. They postulate that some secretion, distinct from the iodine containing substance of the thyroid, is carried to the thymus via the closed lymphatic system. It is hypothesized that the thymus collects and detoxifies this substance. To quote: "*We are forced to the conclusion that thyrotoxicosis would seem to be due to a failure of the lymphatic endothelium of thymus and thyroid to effect the natural detoxication of the lymphogenic secretion produced by the thyroid*" (13).

It would be difficult to explain certain well known facts on this hypothesis. If the functional mechanism, which they have hypothesized between these two glands, were operative, then one could logically expect thyrotoxicosis to result from thymectomy in a certain proportion of animals. Such experimental evidence as is available would be entirely contrary to the assumption that the thymus detoxicates some secretion formed in the thyroid. In spite of the considerable amount of experimental work performed to elucidate the functional significance of the thymus, the relationship of this organ to many bodily processes remains somewhat of an enigma. At any rate, hyperthyroidism has not been reported to follow thymectomy.

Clinically it is a well known fact that the thymus is hypertrophied in hyperthyroidism. Some years ago it was proposed that Graves' disease should be treated by thymectomy. This operation has been performed by a number of surgeons and Halsted has collected reports on 500 cases of thymectomy for hyperthyroidism from the literature. In a certain number of these cases marked improvement has followed the operation. Here again, it would seem logical that, if the thymus were concerned in detoxicating something produced by the thyroid, thymectomy in these cases should prove disastrous. In any event, we fail to see how the theory proposed by Williamson and Pearse could explain the good results which have been reported to follow thymectomy in hyperthyroidism.

In a recent article, Warthin reviews the pathological findings in Graves' disease and he suggests a new point of view with regard to the etiology of this condition. He emphasizes the lymphoid hyperplasia as the chief pathological finding in the thyroid of Graves' disease. He looks upon Basedow's or Graves' disease as "pathological reactions potentially predetermined in the individual at birth by virtue of his constitutional anomaly. . . . The development of the Basedowian or Graves' symptoms, in so far as the thyroid is concerned, is but the expression of abnormal reactions of this constitutional anomaly to the conditions of the life of the individual. . . the thyroid gland is not the chief pathogenic factor in these various clinical syndromes (toxic goiter, toxic adenoma, etc.)[1]. . .; it is but an incidental complication or sequela, comparable to the participation in abnormal reactions of other organs and systems dependent upon the constitutional anomaly." Looked at from Warthin's point of view thyrotoxicosis is always found associated with the general pathological picture of the thymicolymphatic constitution. There is besides lymphoid hyperplasia in the thyroid, a hyperplastic or persistent thymus, *general enlargement of the lymph nodes and spleen*, and hypoplasia of the adrenals, heart, and aorta. Among the European workers, Hammar and Hellman (4) have observed enlargement and hyperplasia of the thymus and of lymph nodes generally, in exophthalmic goiter cases.

Warthin's views, then, would be directly opposed to those expressed by Williamson and Pearse to explain the etiology of thyrotoxicosis. According to the former, lymphoid hyperplasia is, along with certain other constitutional defects, the primary condition and only those persons possessing these anomalies will ever develop thyrotoxic symptoms. Williamson and Pearse, however, while recognizing the presence of status thymicolymphaticus in every case of Graves' disease, are inclined to attribute the lymphoid hyperplasia to the excessive production of a lymphogenic secretion of the thyroid. The thymus is conceived as detoxicating this secretion and with excessive formation of secretion the thymus shows hyperplasia. If the latter view were correct, we should expect every case with status thymicolymphaticus to show thyrotoxic symptoms. Such seems not to be the case. Also, if a closed lymphatic system is a

[1] Words in parentheses are ours.

necessary link in the chain, how would these latter workers explain the general enlargement of the lymph nodes in cases of Graves' disease?

SUMMARY AND CONCLUSIONS

We have studied the lymphatic connections of the thyroid with a view to determining the presence or absence of a closed lymphatic connection between it and the thymus gland. Careful dissections made on seven human cadavers failed to reveal anything which might be interpreted as a closed lymphatic system between these structures. Similar negative results were obtained in seven experiments in which the thyroid of unembalmed cadavers was injected with India ink or Gerota's fluid and the course of the lymphatics observed.

We may summarize our main findings as follows:

1. In the human cadaver, lymph vessels were observed to emerge from the superficial surface of the thyroid and enter nearby lymph nodes. From these nodes, vessels enter the right lymph duct or the thoracic duct.

2. Lymphatic vessels from the thymus gland can be traced to the superficial and deep cervical nodes and efferent vessels from these enter the right lymphatic or thoracic duct or one of their tributaries. Other lymphatic vessels from the thymus pass to the mediastinum and to lymph nodes along the course of the internal mammary artery.

3. No direct lymphatic connections could be made out between the thyroid and thymus. Lymphatic vessels from both glands may go to the same lymph node, but this condition is rare.

4. Many thin walled veins leave the thyroid at the hilum and these are often difficult to distinguish from lymphatics unless they are traced to their termination.

In one cadaver, following the injection of India ink into the thyroid, microscopic sections taken of the thymus failed to reveal any carbon particles in the thymus.

Injection experiments were performed on six dogs in which Gerota's fluid was injected into the thyroid. Subsequent dissection showed that the fluid failed to penetrate into the thymus even after massaging the thyroid for 5 to 10 minutes.

In two other experiments on puppies histological sections of the thyroid, thymus, and intervening tissue were made subsequent to the injection of India ink suspension into the thyroid. No carbon particles were visible in the sections of thymus.

We may conclude, therefore, that in both man and dog, there is little or no evidence for a direct lymphatic connection between the thyroid and thymus glands. Likewise, there is no evidence for a closed lymphatic system between these structures.

Since our paper was submitted for publication July 13, 1931, two articles (Gordon, S. D., Canadian M. Ass. J., 1931, xxv, 46, and Reinhoff, W. F., Arch. Surg., 1931, xxiii, 783) have appeared on this subject which present evidence substantiating our results.

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THE HEALING OF WOUNDS

An Experimental Study to Show the Influence of Body Dehydration[1]

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THE surgeon's most fundamental problem, according to Carrel (14), is to acquire a full understanding of the process by which wounds heal. This problem naturally divides itself into a consideration of (1) the factors which control the initiation of the process, (2) those factors which control subsequent growth, and (3) those influences which bring about cessation of healing.

It is certain that these forces are multiple and complex and some of them, hidden by incomplete knowledge of the physicochemical processes in tissues, are probably not as yet within our conception.

However, several researches over a period of years have brought forth facts which tend toward the solution of the problem:

1. Aside from the consideration of embryological healing (A. Keith), normal growth, physiological replacement of tissue, and the growth of tumors, it is evident that there must be a wound before healing will begin. This does not mean, however, that because there is a wound, healing is initiated. Carrel (12) showed that, even in a healthy animal, the fibroblastic response in an uninfected area denuded of skin can be completely inhibited for at least 25 days by covering the area with a layer of preserved fascia. It is evidently not the loss of tissue in itself which initiates repair. There is, presumably, an element, or there are elements, within the tissue cells or intercellular fluids, which, on being set free by the disarrangement of cells, and after suitable alteration, "stimulate" the fibroblastic response (Foot).

Loeb considers that repair is essentially a reaction of the tissues to the presence of foreign bodies and that the cells of the tissues surrounding a wound enter the defect by amœboid motion, there to remove foreign particles and to multiply. The researches of Akaiwa, however, suggest that, at least in the case of epithelium, growth is dependent on more than a foreign body stimulus. As is well recognized clinically the bed of an open wound must be in a suitable condition before the epithelium will grow over it (Hartwell).

Carrel and Baker have approached a step nearer the truth by showing that the higher split products of protein digestion, acting either as catalysts or as quantitative factors in the chemical reactions of repair, stimulate growth. Hammett believes the sulphydryl (SH) group, present in some of these higher split proteins, is the essential stimulant.

2. After a wound is made there is normally a period of from 5 to 7 days before the multiplication of fibroblasts and of other tissue elements such as endothelium begins (Carrel and Du Noüy). This may represent the time necessary for the production of the stimulus to growth. Carrel (12) has shortened the latent period in open wounds by applying turpentine, chick embryo pulp, or staphylococci. It seems likely that the higher split proteins are present earlier in wounds so treated.

3. Ebeling, utilizing wounds in the alligator, which is thermolabile, demonstrated that for a rise in temperature of 10 degrees C., the rate of cicatrization was increased about twofold. He concluded that "in spite of the complexity of the factors which bring about the cicatrization of a wound, it appears that the velocity of the phenomenon depends on the rate at which certain chemical changes take place."

4. Bacterial infection interferes with the healing of a wound (Carrel and Hartmann) but may cause in some instances an increase in the total fibroblastic response by inhibiting epithelization and allowing time for the connective tissue to proliferate in the base of the wound. The same is true of the presence of large or infected foreign bodies.

5. Age has its effect on the rate of healing, at least in open wounds (Du Noüy). The supply of oxygen and nutriment, the rate of

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tissue metabolism, and the activity of the removal of waste products are presumably more favorable to healing in young animals than in old. Furthermore, the lipoids of the blood serum extravasated into a wound inhibit healing to a greater and greater extent as age advances (Carrel, 14). But possibly of importance, in the light of the present studies, is the fact that the percentage of water in the tissues decreases progressively from embryonic life to old age (Moulton).

6. Although there may be a sufficient physiological or artificial stimulus to fibrosis, new cells will not form unless the surrounding tissues transmit suitable building materials from the blood stream and transport the waste products from the field of repair.

It is a fact established clinically that wounds heal less rapidly in patients with severe anæmia. Wounds in areas of decreased blood supply, as in a limb affected with marked arteriosclerosis or in tissues which have been extensively treated by X-rays (Frey), heal slowly, and Ellis has demonstrated the inefficient healing of skin divided by electrosurgical methods. On the contrary, wounds in excessively vascular areas, such as the face, heal rapidly. Leriche, and Fontaine and Jung have shown marked acceleration in the healing of wounds made in sympathectomized areas. A less than optimum supply of oxygen for the chemical reactions of repair is presumably the fault in the anæmic and arteriosclerotic patients, in whom also the temperature of the tissues may be subnormal. Conversely, in the face, the oxidation is undoubtedly at an optimum and in the sympathectomized areas the oxidation is ample and the temperature normal or increased (Morton and Scott). Furthermore, variations in the degree of oxidation and alterations in local temperature have their effect on the local hydrogen-ion concentration of the tissues (Haebler, Wilson) and on the adequacy of removal into the blood stream of the waste products of chemical reactions (McIver and Gamble).

Delayed healing is expected clinically in patients with marked nutritional or functional disorders such as diabetes, nephritis, impaired liver function, or starvation from any cause. It may be ascribed to unfavorable local tissue reactions resulting from alterations in the supply of oxygen and food increase in concentration of lactic acid and acetone-bodies, changes in local acidity (Sauerbruch), surface tension, colloidal state of proteins (Girgolaff, Haebler), temperature, and other factors.

7. Controlled experiments have been carried out by Clark, and by Harvey and Howes, which demonstrate, in animals supplied with a protein-rich diet and water *ad libitum*, an acceleration of the healing of granulating and primarily approximated wounds. In particular the latent period is shortened. Protein in all probability increases the rate of healing, (1) by increasing tissue metabolism (Benedict and Carpenter, Clark) (i.e., the rate of chemical change by which new fibroblasts, endothelium, and other elements of the new tissues are formed); (2) by assisting in the proper buffering of the fluids of the wound (Leupold); (3) by supplying immediately the necessary amino acids for the construction of fibroblasts.

Rowntree has remarked that "water reaches every cell in the organism, and through its properties furnishes the opportunity for chemical reactions, for changes in physical state, and for energy transformation." But, although the importance of an adequate body fluid mass (accompanied, as it is with few exceptions, by a proper osmotic, electrolyte, and hydrogen-ion balance) has been recognized in the effective treatment of many acute illnesses (notably by Hartwell and Hoguet, Gamble and McIver, and Orr and Haden in intestinal obstruction; by Marriott, Schloss, Hartmann (37), Hoag and Marples, and Balcar, Sansum and Woodyatt in "inanition fever" and the persistent diarrhœas of infants; by Cannon, Fraser and Hooper, and Blalock (8, 9) in the shock of trauma and of hæmorrhage; and, more recently, by Underhill in the treatment of extensive burns), no one, so far as we are aware, has attempted to investigate the effect of a deficiency of body fluid on the rate of healing of wounds. The following experiments show that, at least in the stomach wall of the rat, a loss of body fluid delays healing.

EXPERIMENTS

We have followed in general the method described by Harvey and Howes. The body

TABLE I.—EXPERIMENT A. EFFECT OF DEHYDRATION ON THE HEALING OF GASTRIC WOUNDS IN RATS.[1]

No.		Original weight	Final weight	Number days post-operative	Bursting pressure	Burst at wound
34	Control	260	230	4	158	—
19	Experimental	263	212	4	131	+
29	Control	268	232	4	151	—
40	Experimental	270	211	4	135	+
16	Control	250	218	6	131	—
42	Experimental	282	207	6	127	+
26	Control	272	250	6	163	—
54	Experimental	253	181	6	126	+
24	Control	206	168	8	159	—
41	Experimental	307	240	8	148	+
18	Control	291	268	8	146	—
38	Experimental	248	160	8	*174*	—

[1] These rats were all unmatched old breeding females. Controls had water *ad libitum*, no food; experimental rats, 5 cubic centimeters water by mouth each day, no food.

Average loss in weight, controls 9.2 per cent.
Average loss in weight, experimental 25.4 per cent.
Average bursting pressure, controls 151.7 millimeters mercury, none at wounds.
Average bursting pressure, experimental 133.4 millimeters mercury, all at wounds.

weights of the rats, and their food and fluid intake were recorded daily. They were all kept on a slightly modified Osborne and Mendel diet. Under ether anæsthesia a transverse incision 1.5 centimeters long was made in the pyloric antrum on the anterior wall of the stomach. This was immediately sutured in two layers with continuous No. 000 plain catgut, a uniform technique being used. Sterile precautions were found unnecessary and there was never any evidence of peritoneal inflammation or infection of the abdominal wounds. From 4 to 14 days after operation, the strength of the wound in the gastric wall, or, in case the wound proved the more resistant, of the gastric wall itself, was estimated according to the following procedure. The rats were killed with ether and their stomachs excised immediately and kept moist with physiologic sodium chloride solution. The œsophageal orifice was tied off securely and a suitable cannula was introduced into the stomach through the pylorus and tied there. The stomach was then distended with air until it burst, and the pressure at the instant of bursting was recorded in terms of millimeters of mercury.

Experiment A. In this small preliminary group twelve unmatched old breeding female rats, aged 500 days and varying in initial weight from 206 to 307 grams (Table I) were used. None was given food, the six controls were supplied with water *ad libitum* and the six experimental rats were limited to 5 cubic centimeters of water each day. On the fourth, and again on the sixth and eighth days, the stomachs of two control and two experimental rats were ruptured and their relative strengths determined. In this group, the cannula in the pylorus was connected to a system in which the air pressure was increased at a constant slow rate. A mercury manometer and a kymograph served to indicate the pressure at the instant each stomach ruptured.

Experiment B. This experiment was similar but we used 36 full grown, standardized, litter-mate, male, albino rats, aged 365 days, and each weighing between 232 and 340 grams. Approximately half as much water (average 8 cubic centimeters a day) was allowed the experimental rats as for the controls (average 16 cubic centimeters a day) and the two groups ate practically the same amount of standard food, average 4 and 4.4 grams per day, respectively. Three experimental rats and their three litter-mate controls were killed with ether on the fourth, sixth, eighth, tenth, twelfth, and fourteenth post-operative days. The method of determining the relative strengths of the stomachs and wounds was the same as in Experiment A.

Experiment C. In a third series, 36 smaller, but in other respects comparable, male rats were utilized. (Aged 110 days; weights 150 to 264 grams.) Here, by force of circumstances, it was necessary to use No. 00 instead of No. 000 plain catgut to suture the gastric wounds in the 4, 6, and 8 day rats. No. 000 plain catgut was used for the 10, 12, and 14 day animals. The experimental rats received an average of 4.9 cubic centimeters of water per day and the controls 13.2 cubic centimeters, the experimental animals 4.8 grams of food and the controls 6.6 grams. In this group and in the series to follow, in order to burst the stomachs, we introduced a definite and constant amount of air into the system per unit time, a slight variation in technique which was simpler and just as satisfactory as the method used in Experiments A and B. Recordings were made in millimeters of mercury of the pressure at the time of rupture of either the wounds or the stomach walls.

Experiment D. In the final series we used 36 female rats of standard stock, entirely comparable to those utilized in Experiments B and C. Their initial weights ranged between 155 and 212 grams, and they were 245 days old. No. 000 plain catgut was used for all suturing. The experimental rats received on the average 5 cubic centimeters of water by mouth each day and the controls 10.4 cubic centimeters; the experimental animals ate 5.0

grams of standard food per day and the control rats 4.6 grams.

RESULTS

Experiment A (Table I) shows the marked weakening of the gastric wounds by starvation plus dehydration, as compared with starvation alone. This is evident in the 4, 6, and 8 day rats though there is an obviously erroneous figure in the second 8 day experimental rat which should be disregarded. The average percentage loss in weight of the control rats is 9.2, of the dehydrated animals 25.4. The average bursting pressure of the control stomachs is 151.7 millimeters of mercury and of the stomachs of the dehydrated rats (ignoring the figure which is in error), 133.4 millimeters. A most significant fact is that in all five instances the stomachs of the dehydrated animals ruptured at the wounds whereas in the animals adequately supplied with water all of the stomachs ruptured elsewhere than at the wounds.

The data and results in Experiments B, C, and D are visualized in Figures 1, 2, 3. The body weights, the food and fluid intake, and the intragastric pressure at the instant of bursting have been averaged for the various animals of like groups to supply a single figure for each 2 day period from the fourth to the fourteenth postoperative days. As shown, the average body weights of the control and experimental animals are almost identical on the day before operation when both groups are on a standard diet with water *ad libitum*. But with dehydration the weights of the experimental animals assume a level consistently lower than those of the control animals.

In Experiment A, accompanying the dehydration and while on a diet identical to that of the controls, the dehydrated rats show a marked weakness of their wounds and likewise of their gastric walls in general. There is a comparative reduction in strength, in one or the other, of 53.3 per cent on the fourth day, 49.2 per cent on the sixth, 12.5 per cent on the eighth, 13.5 per cent on the tenth, 24.5 per cent on the twelfth, and 17.7 per cent on the fourteenth postoperative day. On the fourth day, 5 out of 6 ruptures occurred at the wounds, on the sixth day, 4 out of 6, 2 each in the dehydrated and control groups, but by the eighth and tenth days ruptures at the wounds occurred *only in the dehydrated rats*. Thereafter no more wounds ruptured but the gastric walls of the dehydrated animals continued to burst at pressures lower than in the controls.

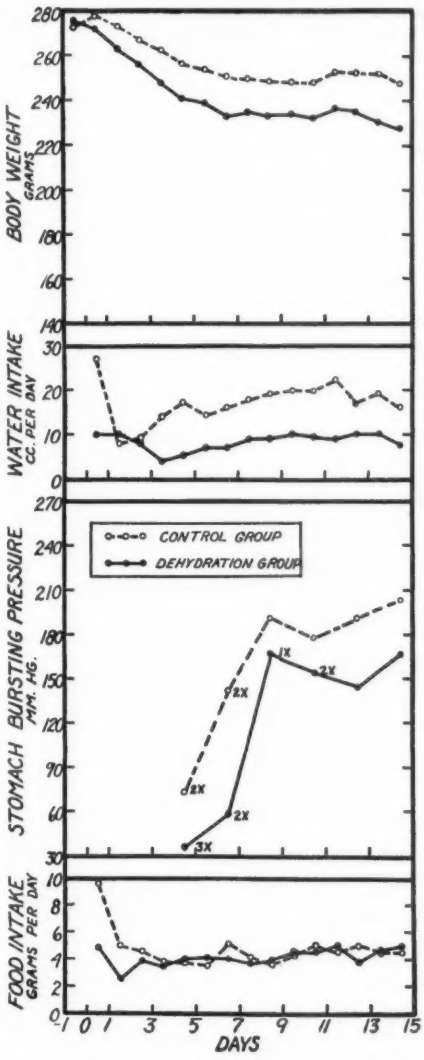

Fig. 1. Experiment B. 1X, One out of three burst at wound, etc.

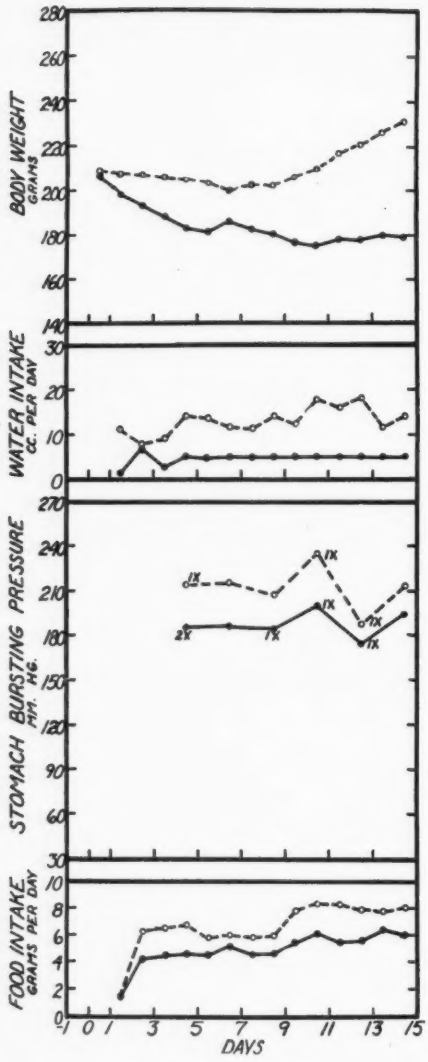

Fig. 2. Experiment C.

Figure 2 shows a fairly striking weakness of the gastric wounds or walls in the young dehydrated male rats. The results in this experiment are open to criticism, however, since the control animals ingested more food than the experimental rats. This may possibly account for the quite marked gain in weight of these control rats, a gain which would normally occur in young animals were it not for dehydration. The surprisingly high bursting pressures of both the control and experimental stomachs on the fourth and sixth days are due apparently to the use in suturing these wounds of No. oo plain instead of No. ooo plain catgut. Harvey and Howes have shown that No. ooo plain catgut has no appreciable strength after 72 hours but this evidently is not true of the No. oo plain catgut.

In the final series, graphically presented in Figure 3, the experiment is very carefully controlled to eliminate the possible effect of varying sizes of catgut and of food. In fact we slightly overfed the experimental rats as compared with the controls. In spite of this the dehydrated animals show a marked reduction in the strength of their gastric wounds and of their gastric walls, i.e., there is a weakening of 39.2 per cent on the fourth, of 19.8 per cent on the sixth, 15.5 per cent on the eighth, 30.5 per cent on the tenth, 5.3 per cent on the twelfth, and 16.5 per cent on the fourteenth day, as compared with the litter-mate controls which were identical in every respect except that they were allowed, on the average, slightly more than twice as much water per day.

DEDUCTIONS

Frequently in our experiments, just as in those of Harvey and Howes, the stomachs ruptured under pressure at points other than at the wound. In the dehydrated animals not only more of the stomachs ruptured at the wound, but throughout each series where the ruptures occurred elsewhere than at the wound the pressure necessary to cause the break was lower than in the rats supplied with adequate fluid. These facts indicate (1) that during the early days of healing the wounds in the dehydrated animals are on the average weaker than in the controls, and (2) that throughout the entire experiment the total strength of the gastric wall in the dehydrated animals is less than in the normal rats. The explanation for the latter finding may be found in the work of Drake, McKhann and Gamble who found that, when utilizing rats dehydrated as a result of pyloric obstruction, although the percentage of water in muscle tissue (of which a large portion of the gastric wall is composed)

is not appreciably lowered, there does occur a considerable reduction in the total mass of muscle. As they remark, this can "only mean a destruction *in toto* of muscle protoplasm producing a corresponding disappearance of water and of substances together."

Although smooth muscle fibers are capable of active regeneration when injured (Berry), the fibrous connective tissue grows much more actively and forms a barrier through which the muscle cells do not penetrate. The resulting healed area is a scar typical for wounds in all tissues of mesenchymal origin. It is fair to suggest that dehydration has a marked inhibitory effect on the processes of repair in general, for example in the healing of grafts.

Delayed healing in dehydrated animals is probably brought about by unfavorable circulatory and nutritional changes in the region of the wound. Moderate anhydræmia results in a decreased blood volume (Keith 45, 46; Gamble; Marriott), peripheral vasoconstriction with decreased volume flow through the tissues (Gesell, Utheim, McIver and Gamble, Marriott), increased viscosity of the blood (Keith, 46; McIver and Gamble; Underhill and Kapsinow, 75), and stagnation of corpuscles in the capillaries (Marriott, Utheim, Cannon, Fraser and Hooper). These mechanical factors tend to decrease the quantity of oxygen and nutriment available for the chemical reactions of repair and to prevent the removal of fluid and substances from the region of the wound. Suboxidation results in a decreased rate of tissue metabolism and alters the speed, form, and direction of many of the chemical reactions involved in healing (Haebler).

Leucocytes have been shown to furnish important proteolytic ferments to an injured area (Carrel, 13). If, as is probable in the stagnant tissues of a dehydrated wound, their migration is inhibited, there will result presumably a dearth of higher split proteins acting as stimulants to the reproduction of fibroblasts. Furthermore, the phagocytic activity of leucocytes and macrophages is lessened in all probability under the influence of dehydration.

Wounds undergoing normal healing are almost universally slightly acid in reaction

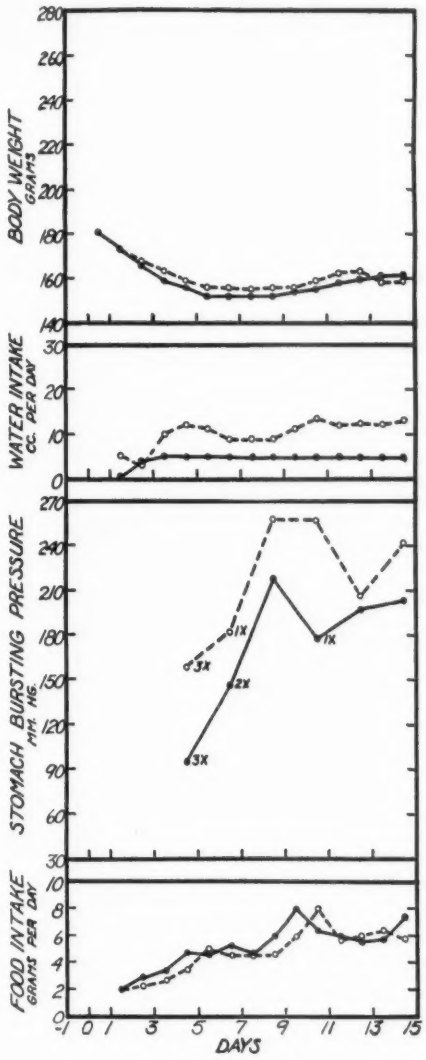

Fig. 3. Experiment D.

(pH 6.97–6.32, Girgolaff, Haebler) and acidity favors repair, [e.g., the dissociation of oxyhæmoglobin is more complete (Wilson) and thus favors both the availability of oxygen and the quick buffering of carbon dioxide on its return to the blood stream.] But Haden and Orr have shown a marked reduction in the oxygen content of venous blood in dogs

dehydrated by means of a high intestinal obstruction. This finding implies a suboxidation of tissues which in turn results in a level of tissue acidity which is far above the optimum. Phosphoric, sulphuric, carbonic, and organic acids, chiefly lactic, are produced in increased amounts, and as a result of diminished volume flow and capillary congestion are only inefficiently removed from the region of the wound.

It is entirely probable that local changes in the amount of free tissue water, in the nature (Gamble and McIver), amount, and concentration of electrolytes, in the total osmotic pressure of the intercellular and intracellular fluids, in the circumstances of surface tension and adsorption at the cell membrane, and in the lipoid concentration of the wound fluids may all influence the reactions responsible for healing. Dehydration obviously may alter any of these relationships and may bring about a localized failure of what Cannon calls "homeostasis."

The moderate dehydration in our rats could not have been sufficient to cause exsiccation of tissue cells. This occurs, probably, only in extremely dehydrated animals near death (Underhill and Fisk, Hill). When dehydration is moderate, tissue acidity as a rule increases, whereupon, according to the principle of Donnan, ionized chlorine shifts from the intercellular plasma to the cells carrying water with it (Van Slyke, Wu, and McLean; Hartmann, 38).

Although Keith and Whelan have proved that, in dogs, dehydration brought about by the intravenous injection of pure hypertonic saccharose or glucose does not cause fever, the injection of only slightly impure sugar or salts does so (Keith, 47; Balcar, Sansum, and Woodyatt), and, clinically speaking, states of dehydration are usually accompanied by fever (Rosenstern, Shoenthal). If a healing tissue were thus subjected to an increased temperature, healing would be favored, but as a rule the harmful factors attributable to dehydration greatly overbalance this apparent advantage. For example, in many instances, even though the body temperature in general is above normal, peripheral areas are probably normal or subnormal in temperature.

Marriott and Spiegler point out that foods, especially fat and protein, probably are absorbed poorly from the alimentary tract during anhydræmia. Although in our experiments the ingestion of food by the dehydrated animals was qualitatively and quantitatively approximately equal to that in the controls, it is recognized that a difference in absorption might alter the conditions of nutrition in the wound. We do not believe, however, that this is a significant factor.

It should be noted that according to the results of Rose, Stucky, Mendel, and Cowgill, anhydræmia is accompanied by gastric atony and anorexia, the more marked the greater the dehydration. In their dogs a complete atony was accompanied by absolute refusal of food. Our rats did not refuse food but had little appetite. Presumably, if moderate atony had any effect on the healing of a gastric wound, it would favor the process by providing rest and relative immobility for the part.

Our effort in these experiments has been to produce a dehydration which would simulate that which might occur in wounded or postoperative patients. Such a dehydration (by limitation of fluid intake) produces, in addition to the unfavorable circulatory changes previously mentioned a slight rise in the hydrogen-ion concentration of the blood (Gamble, Marriott), a more marked rise in the hydrogen-ion concentration in the tissues (Rous and Drury), a rise in percentage of hæmoglobin (Keith, 45; McIver and Gamble; Underhill and Kapsinow, 75), an increase in plasma protein (Peters, Eisenmann, and Bulger; Hartmann, 37; Reiss; Marriott) and an increase in non-electrolytes of the blood such as urea and uric acid (Marriott; MacKay and MacKay). There is little or no alteration in the concentration of electrolytes (Na', K', Mg'', Ca'', HPO_4'', SO_4'') except Cl' which is considerably increased (Schiff, 69; Keith and Whelan). The lactic acid content of the blood is often doubled (Hartmann, 37; Clausen; Schiff, 69), while the ability of the liver to mobilize glycogen is decreased (Andrews), and there may be, possibly as a consequence, a slight increase in the ketone acids of the blood (Moore, Marriott). It should be pointed out that dehydration may be accompanied by a blood stream alkalosis (McIver and Gamble) (e.g., following persistent vomiting from a pyloric stenosis), but under these conditions

the reaction in wounds in peripheral tissues is usually acid, as is suggested by the interesting work of Rous and Drury. Anhydræmic patients have always a marked oliguria and a high specific gravity of the urine but there is no evidence to warrant the assumption of either structural damage or functional deficiency of the kidney itself (MacKay and MacKay, Bessau, Rosenbaum, and Leichtentritt).

If dehydration inhibits the healing of wounds the obvious corollary is that adequate fluid should be supplied during the time of healing. Many individuals ingest habitually a minimum amount of water (MacCordick, Dobson) and may be moderately dehydrated at the time of accidents or, unless care is taken to prevent it, at the time of operation and during the healing period. This is true not only in outlying military hospitals and in the tropics but in civilian hospitals in temperate zones. If there is a loss of body fluid and substances through vomiting, purging (Underhill and Kapsinow, 75), diarrhœa, a fistula, or excessive perspiration, the condition is sharply aggravated. Chronic anæmia or a gross hæmorrhage or shock increases the need for fluids, while the diabetic, the aged, the arteriosclerotic, the victim of thrombo-angiitis obliterans, or Raynaud's disease requires particular attention in this regard whenever wounds are expected to heal in poorly vascularized areas.

The work of Harvey and Howes shows that wounded patients should be supplied with an adequate diet which is fairly high in protein content but we would add that water should be given in quantity in conjunction with the protein: for Schiff (70) has demonstrated that "dehydration intoxication" occurs regularly in exsiccated animals fed on a high protein diet but that the condition does not arise in the event of dehydration on a carbohydrate or fat diet.

DeTakats has latterly criticized the wholesale and routine forcing of fluids, particularly following operations. We believe, however, that continued emphasis should be placed on the need of the organism for water and salts and that except in those individuals with marked cardiac or renal deficiency no harm and much good will come from the administration of from 3,000 to 6,000 cubic centimeters of fluid in each 24 hours immediately preceding and following operation. The amount of fluid which may produce what Greene and Rowntree term water intoxication far exceeds this quantity (Haldane and Priestley, Adolph) provided that enough sodium chloride is supplied to maintain the proper electrolyte and osmotic equilibrium (Moss). In fact, it is impossible to produce water intoxication if adequate and suitable electrolytes are supplied together with the water.

From a clinical standpoint, the most useful criteria of the presence of adequate tissue fluid are a moist, clean tongue and a copious urinary secretion with low specific gravity. It is fair to state that during the time of healing, the specific gravity of the urine should never be allowed to exceed 1.015.

CONCLUSION

The experiments show that moderate dehydration in rats, comparable to states of dehydration observed clinically, result in striking weakness in gastric wounds and in the gastric walls elsewhere than at the wounds. These effects are marked up to at least 14 days after operation, the limit of time to which the experiments were carried.

It is suggested that dehydration has a marked inhibitory effect on the processes of repair in general and that even after as short a period as 4 days there is sufficient destruction of body protoplasm to weaken considerably many tissues, whether or not they have been operated upon.

Such experimental results demand a continued and reiterated emphasis on the value of an adequate supply of fluid for injured patients of all types. It is, of course, important to bear in mind that dehydration can neither be prevented nor cured by water alone. Sodium chloride must be supplied in addition.

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SPINAL ANÆSTHESIA

A Summary of Clinical and Experimental Investigations with Practical Deductions

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IN 1920 we observed that high anæsthesia from the second to the fourth rib could be obtained in shocked patients when half the usual dose of stovaine was injected intraspinally. This led us to study the cerebrospinal pressure of patients suffering with ruptured duodenal ulcer, acute pancreatitis, etc., and we found that the pressure was invariably reduced. We also observed that when patients became fearful and struggled during the injection, we frequently failed to obtain anæsthesia when the full adult dose was administered. In these patients the cerebrospinal pressure was, of course, increased. We felt that the diffusion of anæsthetics injected intraspinally when given in an upright position was intimately associated with the cerebrospinal pressure. These deductions were partially confirmed by clinical observations. By reducing the spinal pressure from that found to 10 millimeters of mercury, we were able to obtain uniformly high anæsthesia by injecting the full adult doses at the third lumbar interspace. The height could be varied by using the same dose at a different pressure—the higher the cerebrospinal pressure the lower the anæsthesia. These deductions were confirmed by animal experimentation in 1922. In addition, we noted that smaller amounts of the anæsthetic solution at lower cerebrospinal pressures gave a shorter period of anæsthesia, but kept the region anæsthetized below the fourth rib. Larger doses at higher pressures gave a more prolonged anæsthesia at lower levels.

Our endeavors to control the height of anæsthesia and degree of shock by using the same interspace and the same degree of mixing, varying the dose with the cerebrospinal pressure, were only partially successful, however, and we concluded that factors other than those recognized up to that time were responsible for the physiologic changes following the giving of the intraspinal injection. That this contention was correct is shown by the report of our experimental work which follows:

Experimental work was begun in 1922 under the direction of Dr. J. E. Sweet, then professor of surgical research at the University of Pennsylvania. From 1926 to 1930 experiments were conducted in the Department of Experimental Pathology at the same institution and in 1931, in the Department of Surgical Research, Temple University. We have operated on approximately 200 dogs, and have always removed the brain and spinal cord at the completion of the experiment to determine the extent of the diffusion of the anæsthetic, the possibility of needle punctures in medulla or cord, anæsthetic in the central canal, or hæmorrhage. If any evidence of trauma was present, the experiment was discarded.

Because of the lack of information in surgical literature on the morphology of the cranium and vertebræ and their contents in the lower animals, we include a brief note on the comparative anatomy of man and the dog.

COMPARATIVE ANATOMY OF THE CEREBROSPINAL SYSTEMS OF MAN AND THE DOG

There is little difference between the protective covering of the brain and spinal cord in man and the dog. The thickness, extent, processes, and attachments of the dura, with one or two exceptions, are identical. In the dog, however, the tentorium cerebelli is a crescentic fold occupying the transverse fissure between the cerebellum and the cerebral hemispheres and is reinforced by the tentorium osseum, a thin flat bony plate 1 millimeter in thickness attached to the dura anteriorly. The dura covering the spinal cord is the same as in the human, the subdural space is smaller, the cord approximating the dura. This is particularly true in the cervical and lumbar regions.

The brain of a large dog weighs from 4 to 5 ounces. The gross appearance of the cerebrum and cerebellum is not markedly different from that of the human, the convolutions, however, are broader and less numerous. The cerebral hemispheres are very broad behind and diminish in width anteriorly; there is a sudden narrowing at the frontal lobes which are flattened laterally. The anterior end of the olfactory bulb projects beyond the frontal lobe. The hypophysis is circular and small; the pons is relatively small; the cerebellum is very broad, but is low and also compressed from before backward. The medulla oblongata is broad and thick. The pyramids are large and prominent.

The spinal cord is almost circular in cross section except at the well marked cervical and lumbar enlargements where it is compressed dorsoventrally. The spinal nerves are arranged in pairs;

8 cervical	13 thoracic
6 lumbar	5 sacral

The central canal is patent, in this respect differing from the majority of human cords and this must be considered when injecting anæsthetics into the subdural space because of the ascent of the drug to the vital centers. There is approximately 20 to 25 cubic centimeters of spinal fluid in the subarachnoid space of a large dog.

While the preceding comparison is lacking in minor details and in accurate description of the finer anatomical points, it shows that the cerebrospinal system of the dog presents no gross dissimilarity to that of the human great enough to preclude its use in studying the effect of the action of various drugs injected into the cisterna and subarachnoid space. The difficulties encountered are technical and due to the morphology of the spinous processes and laminæ. Successful spinal punctures are practically impossible without injuring the cord, or penetrating the central canal.

We have regularly performed laminectomies, with the exception of eight or ten experiments (200 dogs) to insure thorough mixing of anæsthetic solution and spinal fluid and to decrease the possibility of traumatizing the cord. We felt this gave us much greater security in the work we were attempting, although it prolonged pre-experimental procedures. Recently we have seen that H. Dvorak and M. H. Manson (3) have operated on dogs under spinal anæsthesia with about 80 per cent successful injections, but in their preliminary work, they have not mentioned whether trauma was produced in the cord or not.

TECHNIQUE OF LAMINECTOMY AND SPINAL PUNCTURE IN THE DOG

The operative field is prepared in the usual way, the muscles are separated from the spinous processes, subperiosteally, the spinous processes are removed with bone cutting forceps, and a portion of the laminæ with rongeur forceps. We have found that if an opening into the canal be made just large enough to insert a Cozzolini-Allport bone rongeur, the remainder of the operation is simple. At times one is annoyed by a small spurting vessel if considerable bone is removed laterally. This can usually be controlled by fixing a small piece of muscle against it. The dura is covered with a layer of areolar tissue which should be pushed aside with moist gauze. For injection, we use a needle slightly larger than the average hypodermic, which is bent 1 centimeter from the point to a 90 degree angle. The point is then resharpened. Even with these precautions, one may penetrate the cord and force the solution into the central canal.

TECHNIQUE OF CISTERNA PUNCTURE IN THE DOG

The technique of cisterna puncture in the dog is different from that in the human in that one cannot follow the receding occipital bone to the foramen magnum in the dog because of the projection of the occipital condyles. After experimenting with many positions and various types of technique, we have decided that the following is the simplest:

The animal is anæsthetized, placed in a lateral prone position with the head slightly raised, the occiput is shaved and painted with tincture of iodine, the nose is held at right angles to the vertebral column. A point is selected in the midline 3.5

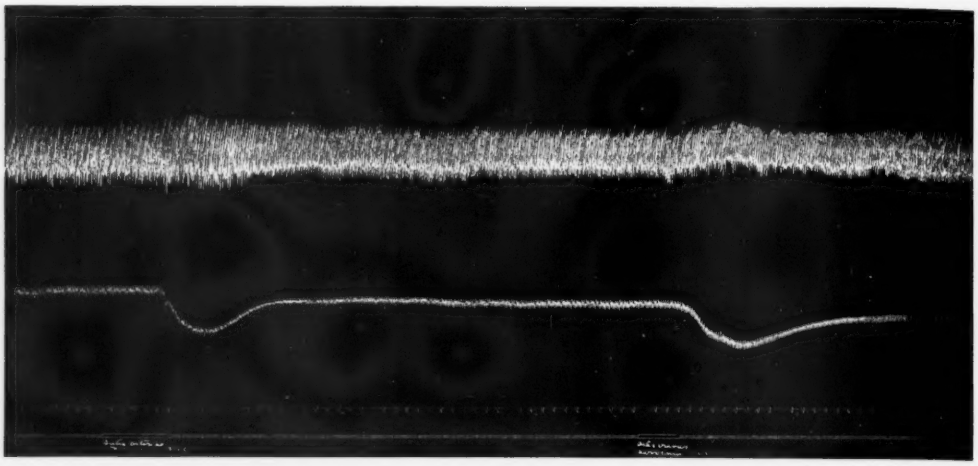


Fig. 1. Effect of stovaine on blood pressure by intra-arterial and intravenous injection. Upper tracing, myocardiograph; next, arterial pressure; time, 5 seconds. Signal.

centimeters below the occipital protuberance. A No. 20 gauge spinal needle with the point slightly beveled is inserted at right angles for a distance of 1.5 centimeters. The stylet is withdrawn; with the tips of the fingers the needle is gradually inserted until cerebrospinal fluid appears. If ether is being used as an anæsthetic and the dog is a normal one, the spinal fluid will spurt from the needle. We have rarely encountered hæmorrhage and are practically always able to mix the anæsthetic with the spinal fluid.

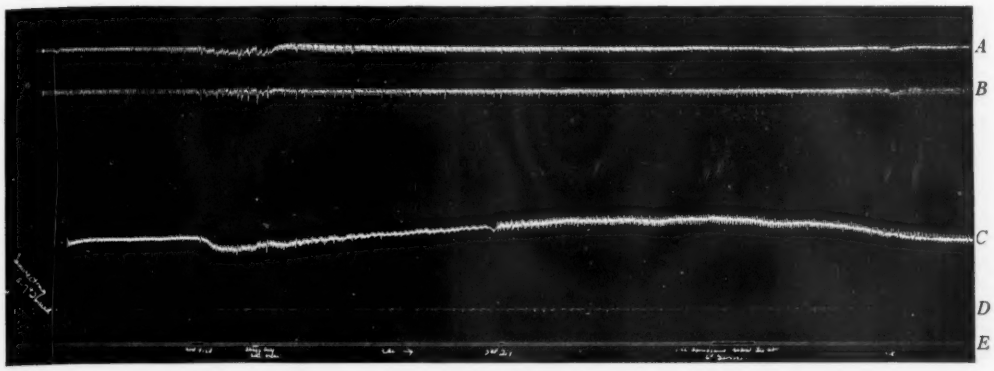
EXPERIMENTAL WORK DURING 1923–1925

In order to determine the height reached by the anæsthetic solution on injection, rosanilin hydrochloride was added. This dye stained the dura mater quite definitely whenever it came in contact with it, and diffused equally with the anæsthetic solution. We determined this by doing a laminectomy under local anæsthesia, giving spinal and then testing the cutaneous sensation by means of the galvanic current.

The spread of the anæsthetic injected into the subarachnoid space is dependent upon (1) the existing pressure of the cerebrospinal fluid; (2) the volume of solution injected; (3) the degree of mechanical intermixing of the injected solution with the spinal fluid; (4) the force with which the injection is made; and (5) to a lesser degree the position of the patient. These factors are controllable and from the experiments made, we concluded that the diffusion of the anæsthetic solution was inversely proportional to the cerebrospinal pressure, other factors being equal, force of injection, volume of solution injected, position of the dog, etc.

A greater cerebrospinal fluid pressure exists at the cisterna magna than at the level of the third lumbar vertebra, with the patient in the sitting position. This is true also in the dog. But if the patient lies on his side and a simultaneous cisterna and lumbar puncture be made and pressures taken it will be found that they are the same. This also holds true for the dog. Such being the case the cerebrospinal system must be hydrodynamic and not hydrostatic. The explanation probably lies in the anatomical construction of the subarachnoid space. We do not have a free cylinder, as it were, of cerebrospinal fluid about the cord, for it is broken at regular intervals by the anterior and posterior roots coming out so that what we really have is an anterior and posterior column with a communication between the nerve roots and also at the cisterna magna.[1] And with changing positions we have mechanical occlu-

[1]By means of a long glass cylinder, rubber tubing and a rubber bag to represent cord and brain, etc., the cerebrospinal system was demonstrated mechanically at the meeting of the American Society for Regional Anæsthetists, New York City, 12–1–25.



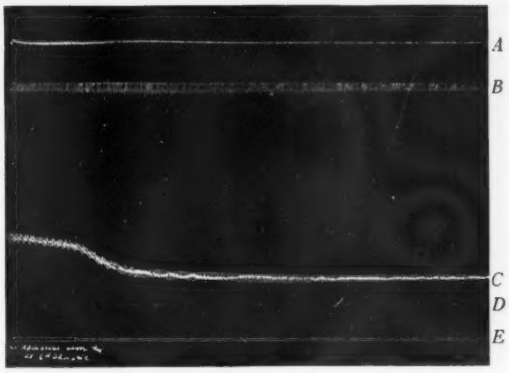


Fig. 2. Effect of novocain strychnine solution on costal and abdominal respiration. Male, weight 19.4 kilograms. Laminectomy fifth to seventh thoracic, cord tied at sixth thoracic, 1 cubic centimeter novocain strychnine solution injected below tie, with very slight drop in blood pressure and slight diminution in amplitude of costal respiration. Later 1 cubic centimeter of same solution injected above tie produced marked drop in blood pressure with almost complete loss in costal tracing and a marked increase in amplitude of abdominal respiration. One-half hour later costal and abdominal respiratory tracing returned to normal excursion as did blood pressure. Dye had reached faintly to fourth cervical. Evidently the amount of novocain contained in the solution was insufficient to paralyze completely the phrenic nerve roots. *A*, costal respiration; *B*, abdominal respiration; *C*, carotid blood pressure; *D*, time, 5 seconds; *E*, signal.

sions and opening of the system. There exists a valvular action in the course of the subarachnoid space.

The absorption of substances from the subarachnoid space is relatively rapid, for phenolsulphonephthalein introduced into the subarachnoid space can be detected in the urine in 25 minutes. Such absorption rate is entirely too slow, however, to produce an immediate fall in arterial pressure following the induction of spinal anæsthesia. However, to rule out the possible effect of the anæsthesia by way of the vascular system, through absorption from the subarachnoid space, intra-arterial and intravenous injection of stovaine solutions were made. Intra-arterial injection produced but a slight transitory fall in arterial pressure. Intravenous injection, on the other hand, caused a more pronounced and prolonged fall with recovery to the pre-injection level in about 8 minutes (Fig. 1). (See work in 1931.) We felt that these facts ruled out a possible effect of the anæsthetic solution by way of the vascular system through absorption from the subarachnoid space.

In attempting to determine the reason for the fall in arterial pressure, we made onconometric readings of the lower extremities of dogs under spinal anæsthesia with negative results, and concluded that a dilatation of the peripheral vessels was in no way associated with this distressing and at times alarming complication of spinal anæsthesia nor could we observe either blanching or hyperæmia of exposed portions of the intestinal tract supplied by the splanchnics.

Further by ligaturing the cord just above the origin of the splanchnics (sixth dorsal to second lumbar) we obtained evidence of splanchnic stimulation with hyperperistalsis, vomiting, etc., without any fall in arterial pressure. By doing two laminectomies and segmenting the cord with ligatures in the region

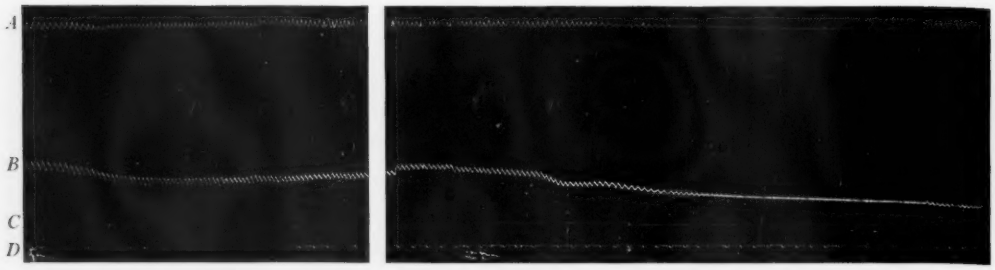


Fig. 3. Novocain strychnine solution—effect of high and low spinal injection. Male, weight 10 kilograms. Laminectomy eighth thoracic subarachnoid space segmented by ligature in this location. Two cubic centimeters novocain strychnine solution below ligature produced practically no change in respiration and but very slight fall in arterial pressure. Two cubic centimeters same solution above ligature produced sharp drop in blood pressure and cessation of respiration in 1¾ minutes; voluntary respiration returned 1 hour and 17 minutes after artificial respiration was begun. *A*, Thoracic respiration; *B*, arterial pressure (carotid); *C*, signal; *D*, time intervals (5 seconds).

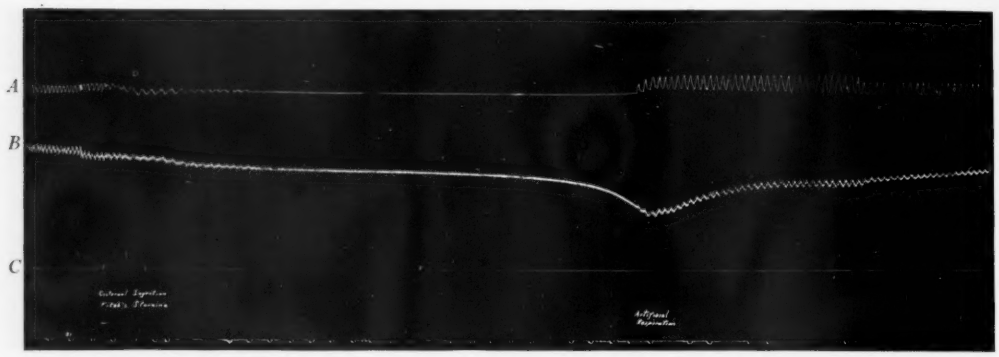


Fig. 4. Stovaine solution No. 3—cisternal injection. Male, weight 6 kilograms. Cisternal injection of 2 cubic centimeters stovaine. Respiration ceased in 35 seconds. Gradual fall in arterial pressure with recovery under artificial respiration. Voluntary respiration returned 16 minutes after injection. *A*, Thoracic respiration; *B*, arterial pressure (carotid); *C*, signal; *D*, time intervals (5 seconds).

of the fifth thoracic and first lumbar and then injecting stovaine solution, we could still not demonstrate to our satisfaction that the splanchnics were operative in the fall of arterial pressure. For by tying the ligature in the first lumbar segment sufficiently snug to obliterate the subarachnoid space and then injecting stovaine below, no fall in blood pressure was recorded. Obliterating the subarachnoid space at the level of the fifth thoracic by the same means and injecting the stovaine into the upper thoracic region of the cord, above the fifth thoracic segment, we obtained a much greater fall in blood pressure with an immediate effect on respiration (Fig. 2). While we realized these two findings were not conclusive evidence against a vasodilatation of the splanchnic area being concerned in the fall in arterial pressure, other significant findings claimed our attention (1).

We realized by now that respiratory embarrassment was intimately associated with the fall in blood pressure and subsequent experiments confirmed this very conclusively. We made simultaneous tracings of carotid arterial pressure by means of a mercury manometer and of respiration by placing pneumographs around the chest and abdomen in connection with recording tambours, for the costal and diaphragmatic respiratory movements, respectively. By ligating and segmenting the cord as described, we could demonstrate this very definitely. Stovaine injected below the thoracic cord, in amounts previously

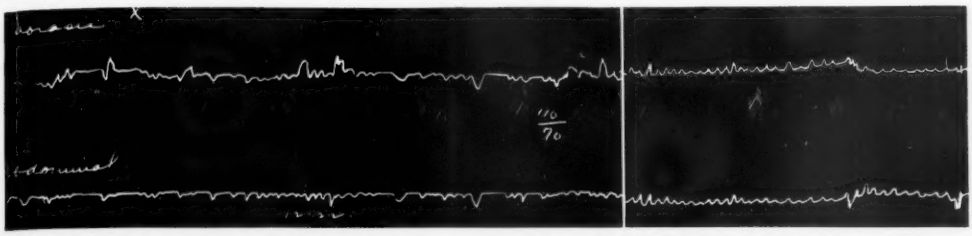


Fig. 5. Effect of low spinal, eighth thoracic, in human on costal and abdominal respiration. Upper tracing costal, lower abdominal. Tracing at left, shortly after injection of stovaine; at right, 30 minutes later, neither showing any change in respiratory excursion.

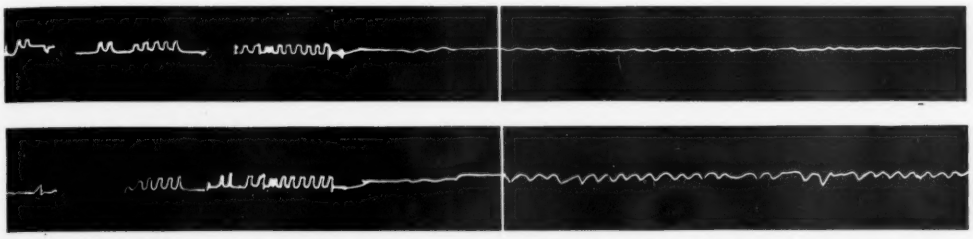


Fig. 6. Effect of high spinal, fourth thoracic, in human on costal and abdominal respiration. Insertion of radium for carcinoma of cervix. Upper tracing costal, lower abdominal. Tracing at left, before injection of stovaine; at right, after injection of stovaine with complete loss of costal respiratory excursions.

proved to cause a drop in blood pressure if injected high enough, caused no change in either respiratory tracings or arterial pressure. Stovaine injected in the thoracic region would paralyze the intercostal nerves and although there would be an immediate impairment and rapid loss of all respiratory movements of the chest wall and thoracic tracing, together with a marked fall in arterial pressure, abdominal respiration would still persist unimpaired. If, however, stovaine were injected high in the thoracic cord, so that it diffused both low enough to paralyze the intercostals and high enough to paralyze the phrenic nerves, and consequently the diaphragm, then there would be almost immediate cessation of all respiratory movements, costal and abdominal (diaphragmatic) and a more marked fall in arterial pressure (Fig. 3).

If the anæsthetic solution had not paralyzed the medullary centers, then there would be a slight asphyxial rise in blood pressure after the original marked drop, due to stimulation of the vasomotor centers by the circulating carbon dioxide. When the center became fatigued the blood pressure fell and the dog died. If, however, artificial respiration were employed before the center tired, the animal could be kept alive until voluntary respiration returned, provided artificial respiration was instituted soon enough. Repeated experiments confirmed this.

If cisternal puncture was used for injecting the anæsthetic, then we would have an immediate asphyxial rise in arterial pressure, unless the drug employed was too toxic for the vasomotor center. If artificial respiration was not used, the animal would die, but by artificial respiration alone, we could invariably keep the dogs alive until voluntary respiration returned (Fig. 4).

These experiments convinced us that the most important danger signal in spinal anæsthesia was embarrassment in respiration and that the alarming drop in blood pressure, which was being watched so closely clinically, was of secondary importance.

With this fact in mind we followed several patients to the operating room and made thoracic and abdominal tracings in exactly the same manner as in our experimental work.

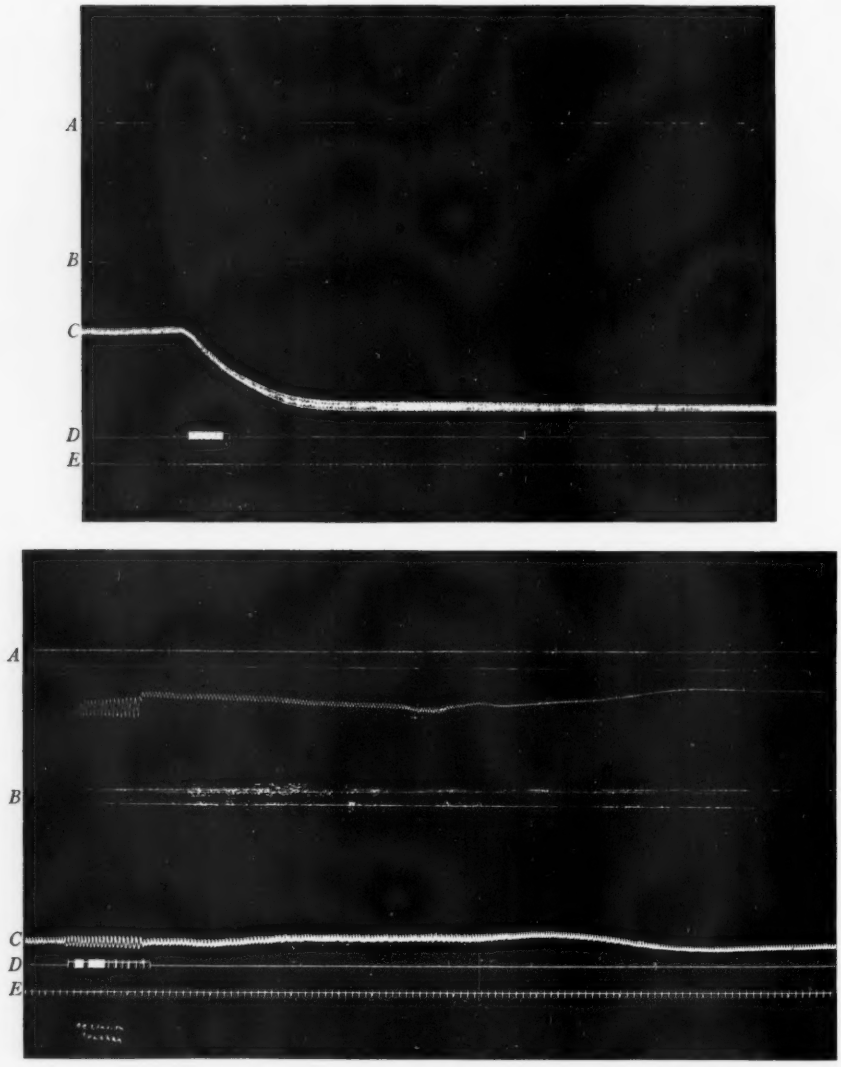


Fig. 7. Superior and inferior vena cava tracings showing rise in pressure in superior and fall in inferior following intraspinal injection of stovaine. Male dog. Laminectomy eighth to ninth dorsal; .04 gm. stovaine injected. Immediate drop in arterial pressure. No marked change in inferior caval pressure. Twelve millimeters (citrate) rise in superior caval pressure. Thirty minutes after injection no change in inferior caval pressure. Sixteen millimeters (citrate) rise in superior caval pressure, increasing to thirty-six millimeters (citrate) 7 minutes later. Dye ascended to the seventh cervical. *A*, Superior vena cava tracing, citrate medium and air bellows; *B*, inferior vena cava tracing, citrate medium; air tambour; *C*, carotid tracing (Hg.); *D*, signal; *E*, time (5 seconds).

except that we used ink tracings instead of a smoked drum and we found exactly the same results. If the anæsthesia was kept below the sixth or eighth thoracic segment, there was practically no change in respiratory movements of the thorax or abdomen and only a

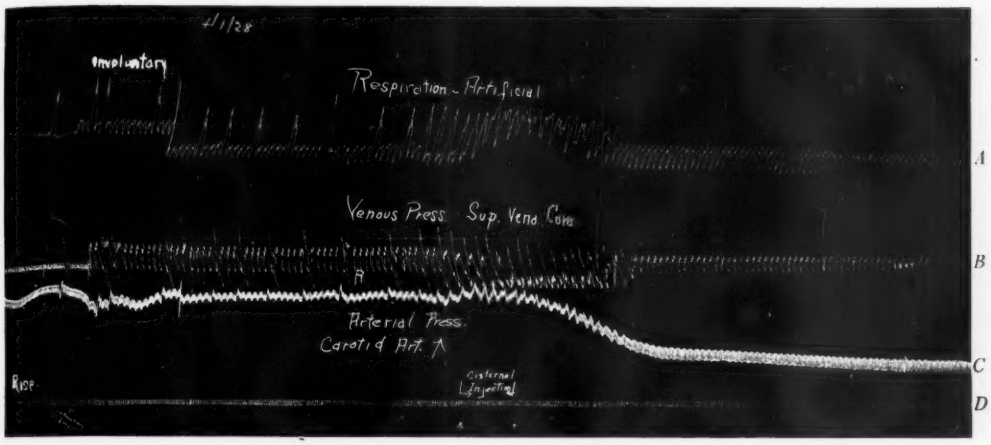


Fig. 8. Carotid and superior vena cava tracings showing rise in pressure in superior vena cava during fall in arterial pressure. April 1, 1928. Male dog, 10 kilograms, ether anæsthesia. Cisternal injection 2 cubic centimeters stovaine solution No. 1. Tracing shows an immediate fall in carotid blood pressure and rise in superior caval pressure, autopsy showed absence of blood in cisterna and no injury to medulla. *A*, Respiration tracing; *B*, superior vena cava tracing; *C*, carotid tracing; *D*, time (5 seconds).

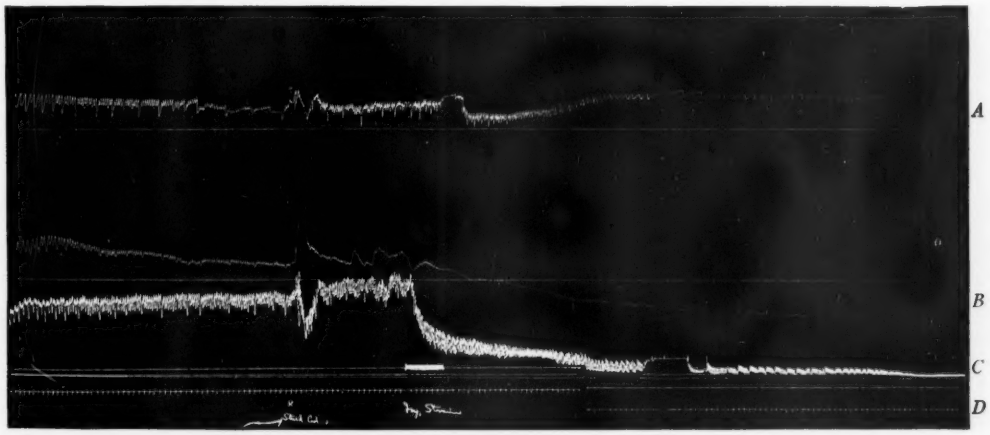


Fig. 9. Carotid, superior and inferior vena cava tracings showing rise in pressure in superior and fall in inferior following intraspinal injection of stovaine. Decerebrate dog. Laminectomy, eighth, ninth, tenth thoracic. Injection 1 cubic centimeter stovaine solution No. 1. Immediate fall in arterial and inferior caval pressure associated with a rise in superior caval pressure. Autopsy showed dye had ascended to fourth cervical and had not penetrated the central canal. *A*, Superior vena cava tracing, citrate medium, bellows recorder; *B*, inferior vena cava tracing, citrate medium, tambour recorder; *C*, carotid tracing (Hg.); *D*, time (5 seconds).

slight fall in blood pressure (Fig. 5), but if the anæsthesia reached the second rib, there was almost a complete cessation of costal respiration (with maintenance of diaphragmatic and abdominal) and a greater fall in blood pressure (Fig. 6). Very slight and very occasional excursions could be seen in the costal tracing, usually in association with larger excursions in the abdominal tracing, and we thought these were reflections from the lower ribs from the attachment of the diaphragm (2).

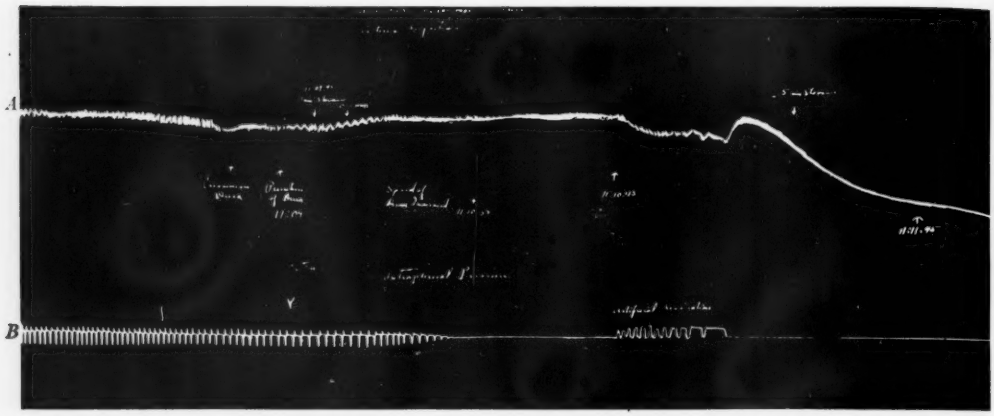


Fig. 10. Carotid and respiratory tracings showing asphyxial rise in blood pressure, with lowering during artificial respiration and secondary asphyxial rise on cessation of artificial respiration followed by subsequent fall and death. November 22, 1925. Male dog, weight 8.4 kilograms, ether anæsthesia. Cisternal injection 1 cubic centimeter stovaine solution No. 1—autopsy showed no injury to the medulla. *A*, Carotid tracing; *B*, intrapleural pressure tracing (Jackson's pleural cannula).

EXPERIMENTAL WORK DURING 1926–1928

The most alarming feature of spinal anæsthesia is the fall in arterial pressure, and in our experimental work we consistently failed to obtain a fall in blood pressure unless a sufficient number of intercostal nerves had been anæsthetized to embarrass thoracic respiration. Usually, though not invariably, respiratory embarrassment preceded the fall in arterial pressure.

To determine the reason for this associated fall in arterial pressure, we made simultaneous arterial and venous pressure tracings from both inferior and superior vena cava. Suitably bent and paraffined glass tubes were passed up the lumen of the femoral and iliac veins to the inferior vena cava, and down the external jugular vein to a point just below its valves. These were connected by pressure tubing with a Brodie bellows, with the interposition of a column of air between the bellows and the citrate solution in the glass tubes. This allowed us to record on the kymograph drum all fluctuations of pressure within each cava. We found that an increase of pressure within the inferior vena cava did not accompany the most profound fall in general arterial pressure, and we took this to be presumptive evidence that splanchnic dilatation was not responsible for the fall in blood pressure. On the other hand, simultaneous with the embarrassment of respiration and fall in arterial pressure, there occurred an alteration in the pressure within the superior vena cava (Figs. 7, 8, 9). The venous pressure within this great cistern tended to rise and approach zero or atmospheric pressure as respiration diminished, and, as the respiratory embarrassment continued to complete cessation, the superior caval pressure became progressively more and more positive although the heart continued to beat quite forcibly.

We considered the following as a possible explanation for this: The pooling of blood in the lungs with failure of the left heart to obtain an adequate volume of blood, because of the absence of the pulmonary lung action. Such a phenomenon, if existing, would dam back the venous blood into the right heart and the great vessels of the chest, producing in them an increase of both blood volume and blood pressure.

We realized that these possible explanations were opposed to the current concept of the physiology of the heart-lungs-blood-flow mechanism, but were further influenced by noting that the rising pressure in the superior vena cava, after the induction of spinal anæsthesia, could be decreased by artificial respiration. This was confirmed not only by venous

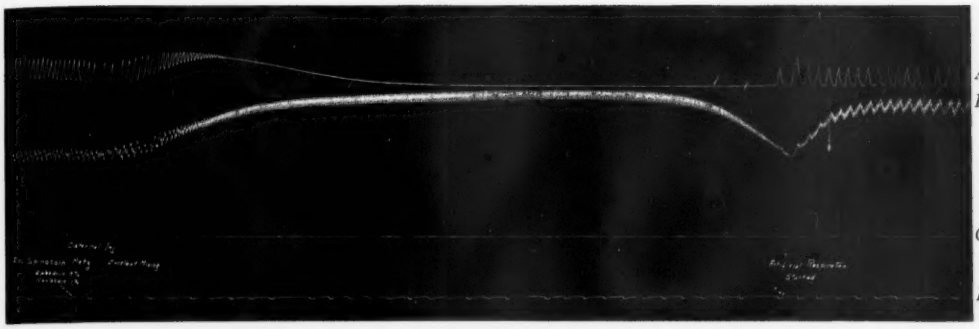


Fig. 11. Novocain strychnine solution—cisternal injection. Female, weight 9 kilograms. Cisternal injection of 2 cubic centimeters of novocain strychnine solution. Respiration ceased 40 seconds after injection, gradual rise of arterial pressure, after injection, persisting for 3 minutes. Voluntary respiration returned 12 minutes after artificial respiration was begun, or 18 minutes after injection. Voluntary movements returned in 19 minutes. *A*, Thoracic respiration; *B*, arterial pressure (carotid); *C*, signal; *D*, time intervals (5 seconds).

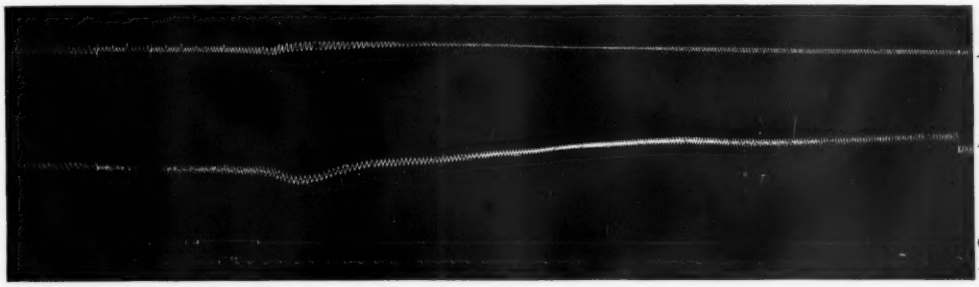


Fig. 12. Neocaine cisternal injection. October 1, 1930. Female, weight 9 kilograms. Cisternal injection of 2 cubic centimeters of neocaine. No cessation but diminution in amplitude of respiration, returning to normal excursion about 3 minutes after injection. Permanent rise in arterial pressure after injection. *A*, thoracic respiration; *B*, arterial pressure (carotid); *C*, signal; *D*, time intervals (5 seconds).

tracings in conjunction with pneumographs, but also by using a Jackson's intrapleural cannula (Fig. 10).

EXPERIMENTAL WORK DURING 1930

Between the years 1927–1930 there had been a noticeable increase in the use of spinal anæsthesia, in hospitals in which it had seldom been used before. There were many more anæsthetic solutions on the market and different commercial houses were preparing the same drug, some in ampule form and others in crystalline form. Further, it had been noticed that indifferent and at times unreliable results were being obtained from the same drug supplied by different firms, and lastly, deaths had occurred in the hands of skilled spinal anæsthetists who had had many years' experience with this type of anæsthesia. This may have been due in part to the enthusiasm of certain firms in advertising anæsthetic solutions and special formulas without adequate preliminary experimental investigations. These facts led us to study, in the fall of 1930, the action of different anæsthetic solutions.

We attempted to gauge the relative potency and toxicity of several commercial anæsthetic solutions by using the full amount of the drug contained in the ampule and timing the disappearance of all respiratory movements and the period of artificial respiration required before voluntary respiration was resumed. We realized that this would not be recognized as a valid pharmacological assay, because different solutions contained more drug per cubic centimeter, but it would give a relative

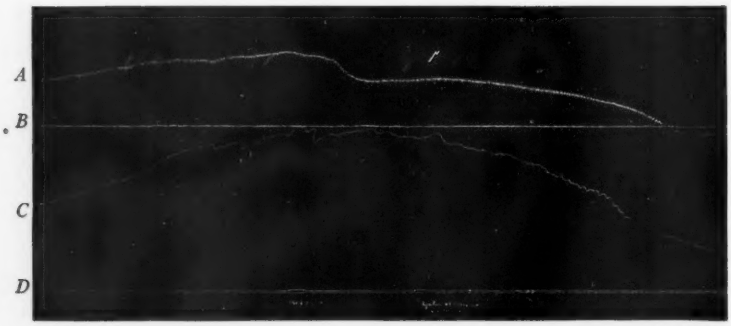


Fig. 13. Plethysmograph and blood pressure tracings showing effect of spinal anæsthesia on splanchnics. Female, weight 19.2 kilograms. Laminectomy sixth to eighth thoracic, cord ligated, plethysmograph tracing from 15 centimeters of ileum in Livingston's oncometer. Injection of 2 cubic centimeters stovaine solution No. 2 below ligature, gradual fall in carotid pressure after injection, with cessation of respiration in 2 minutes and 45 seconds. Volume of ileum paralleled fall in blood pressure. *A*, arterial pressure (carotid); *B*, thoracic respiration; *C*, plethysmograph (ileum); *D*, signal; *E*, time intervals (5 seconds).

indication from the standpoint of their action on respiration, which is the greatest danger in spinal anæsthesia. The full 2 cubic centimeters of anæsthetic solution were given, with sufficient rosanilin hydrochloride added to stain the dura and these were all administered by the cisternal route. We had previously determined that an equivalent amount of salt solution or other inert fluid would cause but transitory changes in either blood pressure or respiration; no more, in fact, than would be caused by simple cisternal puncture. We chose the cisternal route because we wished to get the most rapid and toxic effect possible on the respiratory center and nerves governing respiratory movements.

In general we found that artificial respiration was the most efficient method of resuscitation, and the only stimulation necessary to effect recovery, provided it was begun before the respiratory center had ceased to function and was kept up long enough. Measuring the toxicity and potency of the drugs employed by the rapidity of loss of respiration and length of time necessary for recovery with artificial respiration, we found that they ranged themselves in the following sequence: Butyn, stovaine (different commercial preparations), nupercaine, spinocaine, apothesine, novocain (different commercial preparations) and least toxic neocaine (Figs. 11 and 12).

EXPERIMENTAL WORK DURING 1931

In the late summer or early fall of 1930, Drs. Ferguson and North (4), working in Dr. I. S. Ravdin's laboratory, had excised the splanchnic ganglia in dogs and after recovery had induced spinal anæsthesia with no different results in arterial pressure findings than occurred in dogs with intact splanchnic ganglia. This confirmed our previous statements of 1925 and 1928 based on negative findings. We again confirmed these findings in 1931 by the plethysmographic tracings of dogs' kidneys and portions of the ileum, using Livingston's oncometer (Figs. 13, 14, and 15). In no experiment could we demonstrate a constant increase in volume of the contained organ, which would have happened had splanchnic dilatation occurred.

In discussing the problem with Dr. Livingston, he suggested the use of myocardiographic tracings on the exposed heart, since most of our data pointed toward intrathoracic conditions, being chiefly concerned with the marked fall in arterial pressure.

We have performed myocardiographic tracings on the exposed heart of dogs, in conjunction with arterial carotid tracings and have been able to demonstrate in all experiments to date that the fall in arterial pressure following the intraspinal injection of the commonly used anæsthetics—stovaine, novocain, etc.—is asso-

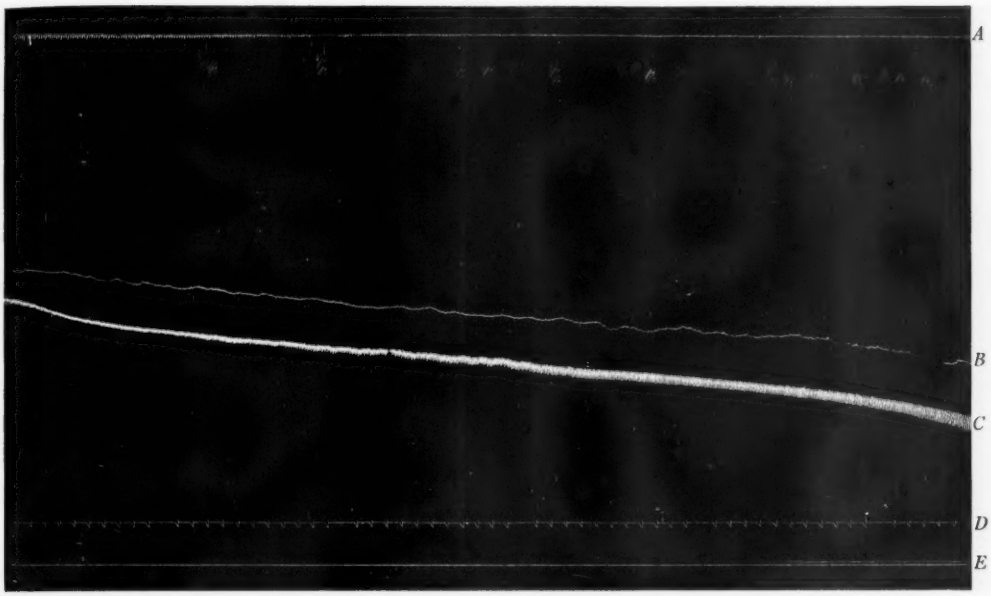


Fig. 14. Plethysmograph tracing showing decrease of intestinal volume following intraspinal injection of stovaine and subcutaneous injection of ephedrin. Dog, weight 15.3 kilograms. Laminectomy, fifth to seventh dorsal. Ephedrin ¾ gram given subcutaneously 8 minutes before stovaine .08 gram stovaine No. 2. Gradual fall in arterial pressure and volume of ileum, respirations decreased in amplitude and almost stopped. Second injection of ephedrin given 6 minutes after stovaine. Artificial respiration started, blood pressure rose, also plethysmograph; voluntary respiration resumed in 12 minutes. Dye reached to the second cervical. *A*, respiration; *B*, plethysmograph (ileum); *C*, carotid; *D*, time (5 seconds); *E*, signal.

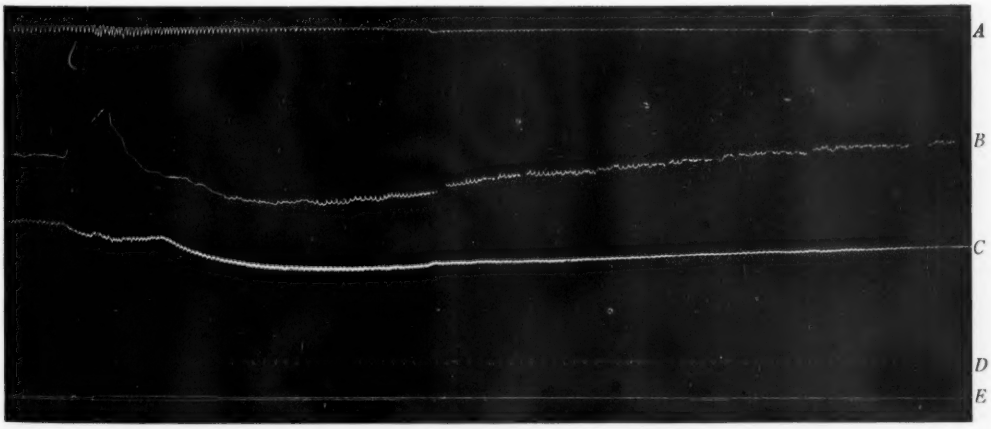


Fig. 15. Plethysmograph tracing showing no change in volume of intestine following intraspinal injection of stovaine. April 27, 1931. Male dog, 11.2 kilograms, ether anæsthesia, laminectomy eleventh thoracic to second lumbar—15 centimeters loop of ileum placed in Livingston's oncometer—injection 2 cubic centimeters stovaine solution No. 3. Slight fall in blood pressure with practically no change in volume of ileum. Diminution in amplitude of respiration but recovery without artificial means. Dye ascended to seventh cervical—autopsy showed that dye had not penetrated central canal. *A*, respiration; *B*, plethysmograph (ileum); *C*, carotid; *D*, time (5 seconds); *E*, signal.

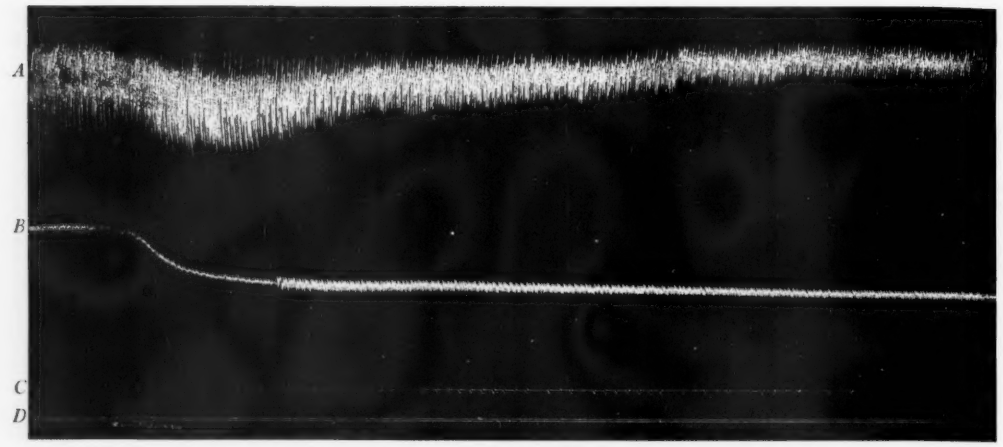


Fig. 16. Myocardiograph—showing effect of stovaine below level of fourth cervical. Male dog. Weight 11.2 kilograms. Laminectomy. Artificial respiration throughout. .08 gram No. 2 stovaine. Immediate fall in carotid pressure; decrease in amplitude of myocardiograph together with rise in tracing (relaxation of heart muscle) within two minutes after injection. Recovery of preinjection myocardiograph seventeen minutes after injection. Dye penetrated to the fourth cervical. *A*, myocardiograph tracing; *B*, carotid tracing; *C*, time (5 seconds); *D*, signal.

ciated with a dilatation of the entire heart, more particularly the right ventricle, a relaxation of heart muscle and decrease in force of the contraction. This latter appears within about 2 minutes with the drugs used, so far, almost simultaneous with the relaxation and dilatation of the heart (Fig. 16). Moving pictures of this phenomenon have been obtained and show what happens quite dramatically. There is a gradual recovery of the tone of the heart muscle and force of contraction and the original pre-injection condition of the heart is obtained in from 20 to 45 minutes, depending upon the drug used and the height of the anæsthetic, provided there is no previous myocardial damage (Fig. 17). In one dog used there was almost immediate extreme dilatation of the heart with death in about 20 minutes. Histological examination of both right and left ventricle showed definite evidence of a subacute myocarditis with localized areas of cellular infiltration in the interstitial tissue.

In all fairness we must state that in these dogs with myocardiographic tracings, it was necessary to use artificial respiration throughout the experiment, because thus far we have been unable to expose the heart without opening the pleural cavity. There is no assistance from the intrapulmonary and intrathoracic pressure because neither the heart is beating nor the lungs expanding in a closed space. However, under artificial respiration and with the heart exposed, myocardiographic tracings can be made over a period of hours with no change in the cardiac contractions or tonicity of the heart muscle. We feel, therefore, that the opening of the thorax under artificial respiration and simple exposure of the heart, cannot be responsible for the dilatation noted.

Further studies along this line are being continued, different anæsthetic solutions and ephedrin being used to help maintain arterial pressure, and will be reported subsequently.

The results of our experimental work to date have led us to formulate the following course of events as a probable *modus operandi* in death in the spinal anæsthesia:

1. A drug paralysis of cardiac and respiratory nerves leading to
2. Dilatation of the heart and respiratory embarrassment.
3. Cardiac dilatation permits venous stasis and fall in arterial pressure, the former being aided by the respiratory impairment.
4. Anoxæmia is caused by the fall in arterial pressure and diminished respiration, which also aids in venous stasis.

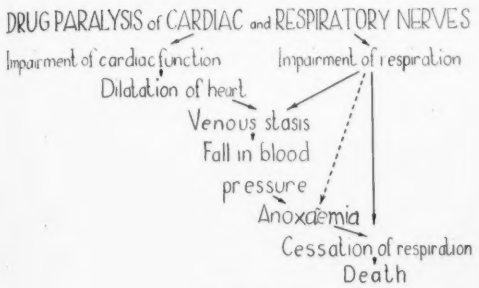


Table I.

5. If no artificial means of stimulation are resorted to, and artificial respiration is all that is necessary, voluntary respiration will cease entirely and the dog will die (Table I).

The sequence of the events as outlined presupposes that the anæsthetic drug has reached the level of the cord supplying cardiac and respiratory nerves. Should the drug not affect the cardiac nerves directly, but only impair respiration, then the sequence of events would be (1) impairment of respiration;(2) venous stasis; (3) fall in arterial pressure; (4) anoxæmia, with its resultant effect on all factors mentioned until the paralytic effect of the drug begins to wear off. In other words, a vicious circle is established and continued as long as the drug acts on the motor respiratory nerves.

To determine the efficiency of the Drinker respirator in treating patients suffering with respiratory failure following spinal anæsthesia and to observe the sucking action of the negative pressure chamber on viscera through an abdominal incision, the following experiments were conducted:

March 18, 1931. *Dog No. 66.* Male, white collie, weight 25 kilograms, Philadelphia General Hospital. Cisterna injection .08 stovaine, lactic acid, .08, alcohol, .02, distilled water to make 2 cubic centimeters, solution colored with analine dye.

The spinal fluid was clear, the anæsthetic solution was well mixed, requiring 18 seconds. There was an immediate paralysis, with diminution of amplitude of respiration. At the end of 2 minutes, respiration had ceased, the animal was placed in the Drinker apparatus and artificial respiration started. Normal excursions were obtained at 20 millimeters pressure. Forty minutes after the injection the animal moved the right masseter muscle. The respirator was stopped and the animal resumed normal respirations. Fifty-seven minutes after the injection the animal voluntarily moved the right forepaw. Shortly after this he was taken out of the respirator. A right midrectus incision was made and a 20 centimeter loop of ileum was placed outside the rectus muscle. The animal was returned to the respirator, but artificial respiration resumed by the negative pressure had no effect on the position of the ileum. The dog was killed with ether.

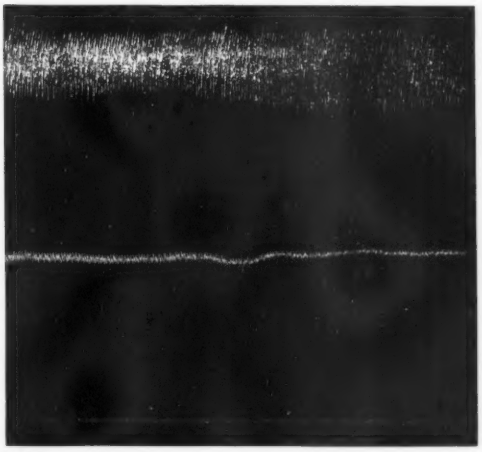


Fig. 17. Continuation of myocardiographic tracing shown in Figure 16, 20 minutes after injection of stovaine. Compare amplitude of excursions of the myocardiograph with those of Figure 16.

Postmortem examination showed that there was no hæmorrhage into the cisterna, the dye had penetrated to the second cervical, and anteriorly to the mammillary bodies.

April 18, 1931. *Dog No. 84.* Female; weight 22.7 kilograms; aseptic procedure throughout. Anæsthetic .08 stovaine (Babcock's solution) without dye. Cisterna injection 9:03 a.m., cerebrospinal fluid clear—mixing time 25 seconds; 9:04 a.m., placed in Drinker respirator, 9:09 a.m., ocular reflexes absent, respirations ceased; 9:10 a.m., respirator started; 9:11, lingual artery not pulsating; 9:12, pulsation in lingual artery returned; 9:20, voluntary respirations returned—animal removed from respirator; 9:31, animal moved forepaws; 10:20, stood on all fours and walked about cage. April 25, 1931, animal in good condition.

These experiments show that the Drinker respirator is a valuable adjunct in combating respiratory failure induced by spinal anæsthesia and that the negative pressure in the cabinet is not sufficient to eviscerate a subject with an open abdominal wound.

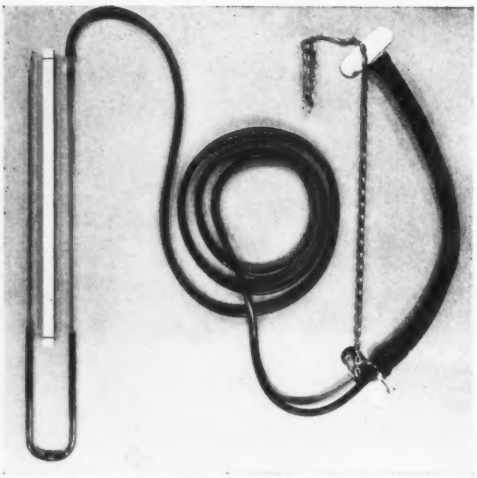


Fig. 18. Respirometer, and ordinary U tube filled with tinted fluid, connected to pneumograph placed about the chest.

TABLE II.—OUTLINE FOR REDUCING ANÆSTHETIC RISK IN SPINAL ANÆSTHESIA

I. Selection of patients—
   Estimation of myocardial reserve most important.
   Contra-indications:—if any two of the following are present spinal should not be given.
   1. Weak or distant heart sounds,
   2. High diastolic pressure, 110 or over,
   3. High pulse pressure, 70 or over,
   4. Electrocardiograph tracing positive for myocardial disease.

II. Development of technique—
   1. Actual instruction,
   2. First induction under supervision,
   3. Familiarity with drug,
   4. Selection of patient, see I.

III. Selection of drug—
   Least toxic.

IV. Early detection of high effect.
   Artificial respiration should begin within 1 minute after respiratory center is affected.

CLINICAL ASPECTS OF SPINAL ANÆSTHESIA

The risk associated with spinal anæsthesia has never been fully recognized because of a misinterpretation of the true cause of the drop in blood pressure and a lack of appreciation of the early effects of the intraspinal anæsthetic on the nerves of respiration. This has interfered with the placing of spinal anæsthesia in its proper category when compared with other anæsthetics. We have always known that the extent of upward diffusion determines the degree of shock. As in ordinary shock the blood pressure falls, the skin becomes pale, the respirations shallow, but no one has written of having seen a suffused or congested intestine during a laparotomy under spinal anæsthesia. Shock is found in those cases in which the anæsthetic ascends higher than the uppermost origin of the splanchnics.

The knowledge that cardiac dilatation with thoracic stagnation of blood may be an accompaniment of spinal anæsthesia makes it possible for us to understand more clearly the catastrophes that have occurred in the past and to outline a routine to follow for selecting and protecting patients in the future who are candidates for spinal anæsthesia (Table II).

We still believe that there is a great deal to learn about the heart and its functional capacity. No outline can in any way take the place of experience, but we believe that it will help those contemplating using spinal anæsthesia to avoid the catastrophes which are not uncommon in one's early experience. The proper evaluation of the risk is most important but some patients will react unfavorably under spinal anæsthesia on the operating table. This happens where the myocardial damage has been of such a character that it escapes pre-operative detection. In this type of case especially, it is essential that high effect be recognized early and we advise the use of the respirometer for this purpose (Fig. 18). While cutaneous anæsthesia will help us to determine the height of anæsthesia, unless the anæsthetist is especially trained in taking care of these patients, she will not make repeated examinations. The surgeon is in part responsible because of his failure to insist on repeated examinations, and there are occasions when the anæsthetist attempts to make observations but the upper level of the anæsthesia may be in the operative field. It must be remembered, however, that the first level of anæsthesia is not final as determined by cutaneous sensation but that usually there is a gradual ascent. We have had cases of delayed anæsthesia in which the anæsthetic ascended to a high level. This we cannot satisfactorily explain. The respirometer indicates to the

surgeon at a glance the depth of the patient's respirations. If they have diminished he reminds the anæsthetist to instruct the patient to perform deep breathing. If voluntary forced inspiration cannot be accomplished by the patient, then forced inspiration should be carried out or the patient placed in a Drinker respirator. Any of these procedures combats collapse by increasing intrapulmonary and intrathoracic pressure, preventing overdilatation of the large venous channels and assisting the heart to empty by pressure from the distended lungs. One of the most unpleasant features following spinal anæsthesia from a subjective standpoint is the inability to breathe, and is responsible for the fear of impending death which some have experienced. This anoxæmia has a decided effect on the respiratory center and the oxygenation of the heart muscle. There can be no objection to the use of adrenalin or ephedrin. As previously stated, however, neither of these drugs has prevented cardiac dilatation nor relieved respiratory embarrassment in our experimental work. In sudden collapse the intravenous injection of adrenalin should be used in addition to forced inspiration. In animals where the respirator has been used within a minute after complete cessation of respiration stimulants have not been necessary.

SUMMARY OF EXPERIMENTAL WORK

1. The fall in blood pressure following the injection of an anæsthetic into the subarachnoid space is not due to a collection of blood in the splanchnic area.

2. When the anæsthetic ascends to the fourth thoracic nerve roots or higher in the dog there is an associated dilatation of the heart.

3. The marked fall in blood pressure is mainly cardiac. Paralysis of the intercostal and phrenic nerves interfere with normal chest expansion and diaphragmatic excursion causing a damming back of venous blood in the right heart and its tributaries. When the ascent of the anæsthetic in the spinal canal is gradual, the blood pressure drops gradually and reaches its minimum in from 15 to 20 minutes. When the anæsthetic ascends rapidly and sufficiently high to affect not only the nerves of respiration but the respiratory and vasomotor centers, the fall in arterial pressure is almost immediate but may be preceded by an asphyxial rise.

4. Sudden deaths following intraspinal injections may be cardiac, cardiac and respiratory, or respiratory.

5. Adrenalin and ephedrin have not prevented cardiac dilatation in our experiments.

6. The Drinker respirator alone will resuscitate an animal that has received the full adult dose of a spinal anæsthetic into the cisterna.

CONCLUSIONS

Practical application of experimental work to clinical usage.

1. Selection of the patient and an early recognition of a high effect are most important from the standpoint of the prevention of deaths.

   a. The foregoing outline we believe should assist in selecting patients for spinal anæsthesia.

   b. A respirometer should be used to determine early changes in respiratory volume following spinal anæsthesia.

2. Safe anæsthesia is the preservation of epicritic and protopathic sensation about the level of the sixth rib. Above this cardiac and respiratory embarrassment may develop.

3. Up to the present time there is no known method of absolutely preventing deaths from spinal anæsthesia, but artificial respiration offers the best means for combating respiratory embarrassment and the fall in arterial pressure.

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POSTOPERATIVE THROMBOSIS, THROMBOPHLEBITIS, AND EMBOLISM[1]

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EVERY surgeon, before undertaking an operation of election, has either a subconscious or conscious dread that an embolus may suddenly cause the exodus of his patient at a time when least expected. Until recently attempts to solve this problem have been concentrated largely on statistical reports. While these reports have shown us the types of patient and the types of lesion which are most prone to result in embolism, they have not given any real light on the etiology or prophylaxis of these catastrophes.

At the Fifth Avenue Hospital during the past 4 years, we have made a concerted study of postoperative thrombosis, thrombophlebitis, and embolism. We have attempted to study the etiology to see if we could adapt therefrom a prophylactic policy. In order to study this problem we have arbitrarily divided the cases into two groups: (1) those caused by physical forces and (2) those caused by biochemical factors.

It is generally accepted that trauma, infection, slowing of the blood stream, and dehydration predispose toward thrombosis. We have classified these as the physical forces. While we admit that infection is not of itself physical, nevertheless it is originated by the physical forces of the original injury or the trauma from operation.

We have felt, however, that there must be another factor, inherent in the individual, of a *biochemical* nature, which would tend to make that individual more susceptible to thrombosis and embolism. This belief is based on the fact that many patients have all the physical forces present and yet do not develop thrombosis, while others with a minimum number readily succumb.

We propose to discuss the physical forces which are concerned in the etiology and the practical measures which have been used in the treatment of operative cases and which in our hands have diminished the incidence of embolism. We also propose to discuss rather in detail our studies on the clotting factors of blood, our experimental and clinical results from this analysis, and to suggest certain lines of treatment which we have found diminish clotting tendencies after operation.

During the past 4 years in which we have been studying thrombosis and thrombophlebitis we have had an opportunity to see a large number of these cases because the various hospitals in New York have been good enough to allow us to study their clinical material.

Phlebitis and thrombophlebitis may be grouped clinically as follows:

1. *Septic phlebitis.* This is a manifestation of a general bacteriæmia usually accompanied by septic infarcts in various parts of the body. As this is a manifestation of a general systemic infection it will not be discussed in this article.

2. *Phlebitis and periphlebitis.* This type, as generally seen after operation, is characterized by a sharp elevation of temperature, which may persist from 5 to 15 days. This rise in temperature is often inaugurated by a chill, and is associated with pain and swelling of the extremities. It is probable that the associated periphlebitis and lymphangitis are largely responsible for the swelling of the limb. Homans has shown that in trying to reproduce this condition experimentally, ligation of the femoral vein does not cause the swelling, but if the adjacent lymphatics in the region of Poupart's ligament are obstructed the cold, swollen leg results which we are accustomed to associate with phlebitis. As this disease is noted early in its onset and as appropriate measures are instituted to put the limb at rest, embolism is not a frequent complication.

3. *Migratory phlebitis.* This is a disease of rather unknown pathology and etiology. It is unquestionably bacterial in origin and may persist, with intermissions, over a period of years. Various veins may become affected.

[1]Presented before the Western Surgical Association, Denver, December 4, 1931.

It is difficult to tell whether the migratory phlebitis, which is so often the concomitant of thrombo-angiitis obliterans, is an independent disease or closely connected with the usual type of migratory phlebitis as seen.

4. *Thrombophlebitis.* It is this type, in which the thrombosis is the predominating factor and the phlebitis a secondary one, that is frequently unrecognized clinically and often results in sudden death from pulmonary embolism. It is in reference to this particular type that we have devoted our biochemical studies.

PHYSICAL FORCES

It would seem advisable to enter into a philosophical discussion of the physical forces of postoperative thrombosis and thrombophlebitis and to attempt to derive therefrom a prophylactic policy. Analytical reports from surgical clinics tend to show that these conditions are more prevalent following operations upon the abdomen and in fat people, and rarely do they occur following operations on the brain and skull. One may ask why this should be, for many large veins must be traumatized in skull operations. I venture to suggest the following factors occurring in their etiology:

a. In abdominal cases, in which the surgical approach has been through the abdominal wall, there is constant motion in the field of repair during the first 48 hours; in operations on the skull, with the rigid skull cap, the field is kept at rest. With every breath taken and with the usual postoperative nausea and vomiting there is a constant thrust and pull on the operative field, which might easily dislodge a thrombus or cause its extension into a larger vein.

b. The approach for an abdominal operation is through an area of subcutaneous fat, while in skull operations there is a relatively small amount of fat. With the insertion of sutures, often under too great tension, and with the application of a tight abdominal dressing, necrosis of the traumatized fat may result. Experimentally we have found in dogs that if fat is taken from the subcutaneous tissues or the omentum and ground up with a small amount of saline in a mortar, the resultant fluid contains approximately 2 to 4 per cent fat. When this emulsion is injected intravenously or intraperitoneally a marked rise in the blood clotting index is produced. The description of this index is given later in the article.

c. Slowing of the blood stream. Since Welch's classical discussion of thrombosis and embolism in Albutt's *System of Medicine*, almost all pathologists and surgeons have accredited the slowing of the blood stream as one of the primary factors in the production of thrombosis. It has been shown that thrombosis rarely occurs in arteries because the circulation of the blood is too rapid. Experiments have been performed in which formalin-prepared arterial segments were inserted in arterial defects without subsequent thrombus formation. Pathological specimens of aneurisms have shown that thrombosis occurs in the portions in which there are eddies; but in cases in which a dissecting aneurism has allowed a rapid flow of blood, thrombosis has not occurred.

Following abdominal operations it has been an almost universal practice to apply tight surgical dressings. The distention which usually follows within 24 hours after operation causes a marked increase in intra-abdominal pressure. If we consider that the return flow of blood in the vena cava is largely due to the suction of the heart and the respiratory movements, this increased abdominal pressure and splinting of the diaphragm must cause considerable stasis in the veins of the lower extremities. Moreover, with the almost universal use of the Gatch bed and the Fowler position, we have the double factors of gravity and constriction in the region of Poupart's ligament increased by the flexion of the thighs and by the lower border of the tight dressings.

d. Infection. Infection or the presence of bacteria or their by-products in the blood stream is generally advanced as another contributing factor in the production of thrombophlebitis and thrombosis. These complications may occur in cases in which, to all apparent gross observation, the operative wound has healed *per primam*. We know that bacteria enter the blood stream through the intestinal walls. With postoperative dis-

tention and slowing down of peristalsis, the bacterial flora of the intestinal canal must multiply to a marked degree. Moreover, it would seem probable that, with the thinning out due to distention of the intestinal wall, more bacteria may enter the blood stream.

e. Dehydration, with resultant increased viscosity of the blood, is another factor mentioned as an etiological cause of thrombosis. It is hard to estimate in the first 48 hours after operation, the increase of fluid output over the fluid intake. With postoperative purgation, increased sweating due to postoperative elevation of temperature, vomiting and urination, the fluid output is tremendously increased. At the same time, the oral intake of fluids is markedly diminished.

TREATMENT

If we base our treatment upon our theoretical concepts of the etiology of thrombosis and thrombophlebitis, the following suggestions are offered for consideration:

1. In abdominal cases every effort should be made to reduce the postoperative nausea and vomiting, in order to keep the abdominal wall and field of operation quiet. In peritonitis and in the high upper abdominal cases the Levin tube inserted through the nostril immediately after the patient has regained his consciousness, greatly reduces vomiting.

2. The approach for an abdominal operation is usually through a layer of subcutaneous fat; care should be taken, therefore, to avoid traumatizing the fat by overzealous pull of the retractors. The irrigation of the fat with ether before closure would seem advisable in order to dissolve out the free particles.

3. The prevention of slowing of the blood stream. Pool in 1913 published an article on "Systematic Exercises in Postoperative Treatment,"[1] in which he illustrated the type of exercises to be used, and recommended that treatment be started on the third day after operation. The motion of the arms and legs would in no way interfere with the healing of the wound, and would tend to improve the circulation.

4. The prevention of infection. In our opinion tight abdominal dressings should be eliminated. G. W. and Kingsley Roberts, of the Fifth Avenue Hospital staff, for years have not used any abdominal dressings and have concealed their wounds with court plaster strips. They have been able to show that their incidence of evisceration or infection has not been greater than when tight dressings are used. It is our custom to apply sufficient gauze to cover the incision and to hold it in place with merely enough adhesive plaster to prevent its moving. No attempt is made to apply pressure, and no abdominal binders are used. During the 3 years this procedure has been followed, there have been only two cases of wound evisceration, which were due, I believe, to other causes. The patients are infinitely more comfortable and their upper abdominal distention is certainly less when pressure is not applied. On the first day after operation all dressings are inspected and any that feel tight are loosened. Even with dressings applied loosely at the time of operation, one is often surprised to see an expansion of at least an inch after the adhesive is cut on the day after operation.

We believe that distention is lessened if food is given early. Theoretically it is logical to assume that if no food is present in the intestinal tract there is no stimulus for peristalsis, and fermentation will take place. If a bolus of food enters the intestine, peristalsis is stimulated, which will carry with it gas as well as solid material. In non-complicated cases, after spinal, ethylene, or gas anæsthesia, the patient is routinely given tea and toast the afternoon following the morning operation.

5. Dehydration. Fortunately, in most clinics the giving of active catharsis the night before operation has been omitted from the pre-operative preparation. Some authors have suggested that the intravenous administration of glucose might be one cause of the increased incidence of thrombosis. Experimentally we have been unable to find any increased clotting factors after glucose administration.

BIOCHEMICAL FACTORS

Physiochemical studies reveal that blood plasma, so long as its constituents are not

[1] J. Am. M. Ass., 1913, Apr. 19.

dissociated by extraneous forces, is a single complex in equilibrium, rather than a mixture of substances. The initial views of Harvey (1633) and of Woodbridge (1886) have come again into their own—"blood plasma is protoplasm and clotting is the last act of living blood."

When blood is shed, the plasma dissociates into substances which yield a clot. During the latent period of dissociation antithrombin is precipitated and prothrombin is activated by calcium ions. The resulting thrombin gels soluble fibrinogen into insoluble fibrin.

It has long been recognized that a clot can be started by throwing out to the periphery the blood platelets when the circulation is slowed down. As these blood platelets clump along some portion of the vessel walls, there takes place a coagulation, forming a red clot around the nucleus of platelets. The great question which comes up is whether this formation of clot can take place with only a slowing of the circulation or trauma, or whether there must be first a change in the blood clotting elements of the blood. Some writers feel that mild damage to the liver stimulates fibrinogen formation. Others think it is an interaction of the liver and the adrenals. One of the most interesting pieces of work in this field was done by C. A. Mills and is concerned with the effect of diet on clotting and basal metabolism. He showed that a carbohydrate and fat diet will raise the basal metabolism but will not increase clotting, while a protein diet not only raises basal metabolism but definitely increases the blood clotting elements, and attributed this to some unknown factor connected possibly with the amino-acids derived from protein metabolism.

In the last few years the German literature has contained numerous articles relative to the chemical changes that cause thrombosis. Zipf stated that freshly defibrinated blood will cause deadly shock when injected intravenously; small quantities (1 to 3 cubic centimeters) cause only a rapid fall in blood pressure. Freund obtained some chemical substances which he called early toxins that he believes are caused by cell deterioration during clotting. These toxins are part of organ extracts and are found in liver, kidney, lung, spleen, pancreas, and heart muscles. By injecting these toxins, Freund claims, damage was done to the walls of the vessels and to the blood composition, especially the platelets. Koenig states that a thrombus always occurs when the platelets do not increase after operation. Koenig believes the poisonous substances from destroyed muscles can be compensated by injection with the person's own blood.

Starlinger and V. Seemen found that a change in the proportion of protein brings about thrombosis, globulin, and fibrinogen increase, while albumin decreases, thereby bringing about a lowering of the electronegative charge.

We felt in the beginning of our work that if we could study routinely the pre-operative and postoperative blood clotting factors of patients undergoing surgical procedures we might find a predisposing cause toward thrombosis and phlebitis. Over 3 years ago Mr. Charles Frueauff, a native of Denver, was good enough to donate a fund for a period of 5 years for the study of some surgical problem. With this fund we were able to employ a full time technician, and with the aid of Dr. Kugelmass, of the Department of Pediatrics of the Fifth Avenue Hospital, we initiated the study of prothrombin, fibrinogen, antithrombin, blood platelets, and platelet lysis as our routine examination of patients admitted into the surgical wards. These examinations have been made before operation and on the fifth and ninth days after operation. As our experience increased we found that the platelet count and the platelet lysis were unnecessary in our determination. By placing the factors tending toward clotting, that is, prothrombin and fibrinogen, as the numerator, and antithrombin (which deters clotting) as the denominator, we have been able to work out a clotting index. As the normal prothrombin index is 1 and fibrinogen 0.5 to 0.7 per cent, and the normal antithrombin index 1, our normal clotting index then becomes 0.5–0.7. We have considered that an index over 1 indicates a tendency toward pathological clotting and values below 0.3, a marked tendency to bleed (Table I).

TABLE I.—The Normal Index of Clotting Function of Blood Is, Therefore, 0.5 ± 0.2. Values over 1.0 Indicate a Marked Tendency to Clot and Values below 0.3 Indicate a Tendency to Bleed.

$$\text{Prothrombin} + \text{Platelets} + \text{Fibrinogen} \rightleftarrows \text{Antithrombin}$$

Expressing this reaction in terms of the law of mass action, we have

$$\frac{[\text{Prothrombin}]\ [\text{Fibrinogen}]\ [\text{Platelets}]}{[\text{Antithrombin}]} = 1$$

Introducing normal values for these substances,

Prothrombin index	= 1
Fibrinogen	= 0.5 per cent
Platelets	= 200,000
Platelets lysis	= 50 per cent in 1 hr.
Antithrombin index	= 1.0

TECHNIQUE OF BLOOD TESTS

1. Nine cubic centimeters of blood are taken from the vein and put into 1 cubic centimeter of 1 per cent sodium oxalate. Blood is centrifuged and the plasma is removed.

2. *Prothrombin index.* One-tenth cubic centimeter of the plasma is placed in three tubes (6.8 by 1.3 centimeters, flat bottom) in a water bath 38 degrees C. and to these are added in series 0.1, 0.2, 0.3 cubic centimeters of 0.5 per cent calcium chloride ×6 parts water. The shortest clotting time in the series is the prothrombin time. The prothrombin index is the ratio of the clotting of the control to that of the patient's blood.

3. *Fibrinogen test* (H. Wu, J. B. C., li). To 1 cubic centimeter of plasma add 28 cubic centimeters of 0.8 per cent sodium chloride and 1 cubic centimeter of 2.5 per cent calcium chloride. Mix and allow to stand 20 minutes. Break up the jelly by shaking slightly and transfer to a dry filter. While filtering insert into jelly a slender glass rod with a pointed end and whirl gently. All the fibrin will stick to the rod. Slip the fibrin off the rod and press it between dry filter paper to remove as completely as possible the adhering liquid. Transfer it to a 15 cubic centimeter centrifuge tube, add 4 cubic centimeters of 1 per cent sodium hydroxide. Place the tubes in a boiling water bath and stir with a slender glass rod until the fiber lump has completely disintegrated. The fibrin has now dissolved, leaving the calcium oxalate in suspension. Add 10 cubic centimeters of water. Mix and centrifuge. Transfer the supernatant liquid to a 25 cubic centimeter flask. Cool under tap. Add 1 cubic centimeter of 5 per cent sulphuric acid, 0.5 cubic centimeter phenol reagent, and dilute to about 20 cubic centimeters. Add 4 cubic centimeters of 20 per cent sodium carbonate solution. Shake, make up to volume with water. Standard is prepared as follows:

Measure 1 cubic centimeter of standard tyrosine solution into a 25 cubic centimeter volume flask. Add 0.5 cubic centimeters of phenol reagent diluted to about 20 cubic centimeters and add 4 cubic centimeters of 20 per cent sodium carbonate. Make up to the volume with water. The standard should be prepared at the same time as the unknown. Let stand for 15 minutes before making the color comparison.

4. *Antithrombin test* (Alfred Hess, J. Exp. Med., xxi). Some of this plasma is recalcified by adding 2, 3, 4, 5 drops of a 0.5 per cent calcium chloride ×6 parts water solution to ascertain general coagulability of plasma. Heat 2 cubic centimeters of plasma to 60 degrees C. Prothrombin is destroyed and fibrin coagulated. Filter off coagulum. Plasma contains antithrombin and no prothrombin. Prepare human plasma from normal case the same as oxalated plasma to be tested. Five drops of this plasma are put into 5 tubes: First is a control; to second tube add 3 drops normal filtered plasma; to third tube add 5 drops normal filtered plasma; to fourth tube add 3 drops of filtered plasma to be tested; to fifth tube add 5 drops of filtered plasma to be tested. All tubes are equalized in amount of addition of 0.9 per cent sodium chloride. Mixtures are allowed to remain in contact 15 minutes at 37.5 degrees C. Plasma is recalcified by addition of 0.5 per cent calcium chloride ×6 parts water, the number of drops which are added having been determined by the general coagulability test. The clotting time is observed at 37.5 degrees C.

The time for the complete examination takes a half hour, but the blood of three different patients can be done in 45 minutes. Routine examinations were made of patients before and after operation because it was obvious that one could not predict before operation which patient might develop thrombosis or thrombophlebitis. In addition the blood of a number of patients has been examined who had developed thrombosis, thrombophlebitis, or embolism.

In analyzing the routine cases examined they may be classified roughly in three groups: (1) Patients with normal postoperative clotting indices and having a normal postoperative convalescence. This group comprised 65 per cent of the total routine cases. (2) Patients with high postoperative indices without obvious peripheral blood vessel lesions, approximately 34 per cent. In reviewing the patients with high postoperative blood factors, almost universally the convalescence has been abnormal, in that there has been a longer continuance of temperature than one would expect and the patients have not clinically progressed as one might wish; for instance, a hernia would have an elevation of

TABLE II.—BLOOD TESTS

Made after (1) Normal Diet, (2) after Forty-eight Hours on a Carbohydrate and Vegetable Diet, (3) after Forty-eight Hours on a Visceral Diet

Dog		Pro-thrombin	Fibrinogen Per cent	Anti-thrombin	Platelets	Index
No. 9949	Normal diet	1.11	0.64	1.16	200,000	0.6
	Carbohydrate and vegetable diet	1.11	0.64	1.16	200,000	0.6
	Protein diet	1.45	1.12	0.95	250,000	1.7
No. 9923	Normal diet	1.00	0.54	1.00	400,000	0.5
	Carbohydrate and vegetable diet	0.74	0.54	1.16	220,000	0.3
	Protein diet	1.00	0.64	0.95	300,000	0.7
No. 9924	Normal diet	1.11	0.64	1.16	220,000	0.6
	Carbohydrate and vegetable diet	1.11	0.28	1.00	135,000	0.3
	Protein diet	1.26	0.69	1.00	210,000	0.9
No. 9888	Normal diet	1.00	0.40	1.16	200,000	0.3
	Carbohydrate and vegetable diet	1.00	0.40	1.16	325,000	0.3
	Protein diet	1.11	0.64	0.95	330,000	0.7

TABLE III.—RESULTS WITH BLEEDING DIET

Name	Diagnosis	Date	Clotting time	Bleeding time	Pro-thrombin	Fibrinogen Per cent	Anti-thrombin	Platelets	Platelet disintegration Per cent	Clotting
W.	Partial nephrectomy for double pelvis of kidney	5–11	4′15″	1′30″	1.38	1.12	1.00	380,000	65	1.5
		5–14	4′30″	2′0″	1.00	0.56	1.04	370,000	60	0.5
		5–21	3′15″	1′30″	1.54	0.69	1.04	420,000	66	1.1
F.	Cystic ovary, chronic appendix	7–26	3′30″	2′0″	0.93	0.56	1.25	500,000	49	0.4
		8–2	3′15″	2′0″	1.38	0.75	1.00	360,000	59	1.0
		8–4	4′0″	2′0″	1.38	1.03	0.75	350,000	65	1.8
		8–7	4′0″	2′0″	0.93	0.46	1.07	265,000	47	0.4

temperature varying from 99.5 to 101 degrees for 8 to 10 days after operation. (3) Patients who have developed thrombosis or thrombophlebitis. In this group we have studied 27 cases, not only in our own hospital but from the wards of other hospitals, and out of these there have been 4 in whom the clotting factors have been high before the development of the phlebitis. Early in our experimental study, when we were examining the blood on the third and fifth day after operation, one patient had a normal clotting index on the fifth day and developed a phlebitis on the eleventh day. We feel confident that if the blood of this patient had been examined on the ninth day, as in our later routines, she would have shown high clotting factors. The other patients were not studied until the symptoms had occurred, and in all of these the indices were high. Besides this group of 27 we have studied 7 patients with emboli, all with high indices, of which 3 showed a high index before the occurrence of the accident and the rest of which were not seen until after the symptoms had developed.

Animal experiments performed on dogs, wherein vessels were ligated—causing thrombosis and necrosis of the organs they supply, such as gall bladders and appendices—reveal an increase in the clotting factors after the operative procedure.

After having proved to our own satisfaction, both clinically and experimentally, that the clotting factors are raised in thrombosis and phlebitis, we attempted to determine whether the elements could be changed by some therapeutic means, and also to find if the altered blood chemistry had any effect upon the clinical course of the patient. It must be understood that the evaluation of the clinical effects of therapy is most difficult in this type of cases: for instance, one cannot foretell whether a patient with high clotting factors and running an irregular temperature

TABLE IV.—INTRAVENOUS THIO-SULPHATE
The Effect of Intravenous Sodium Thio-Sulphate on the Blood Clotting Function
(Dog No. 10334)

Initial clotting index	Experimental procedure—intravenous injection	Final clotting index
0.9	5 c.cm. $Na_2S_2O_3$	0.5
0.67	5 c.cm. $Na_2S_2O_3$	0.45
0.9	10 c.cm. $Na_2S_2O_3$	0.7
0.8	150 c.cm. 5 per cent glucose	0.8
0.8	200 c.cm. 5 per cent glucose	0.8
0.9	20 c.cm. $Na_2S_2O_3$	0.6
0.8	20 c.cm. $Na_2S_2O_3$	0.6
0.8	20 c.cm. $Na_2S_2O_3$	0.55

will or will not develop thrombosis if untreated. In addition, the course of phlebitis varies so greatly in the individuals that it is difficult to ascertain clinically whether any therapeutic measure is of value. Even if one asks a patient if he feels that an intravenous injection has been of any benefit, the mere psychic effect of such treatment and the doctor's own enthusiasm may stimulate an affirmative answer. We have tried to be fair in evaluating our results.

At Dr. Kugelmass' suggestion we studied the effect of diets on human beings and dogs. A diet low in fat and protein will decrease the clotting factors, whereas a diet rich in nucleoproteins will cause a marked increase (Tables II and III). There are difficulties, however, in using diet solely as a postoperative means of treatment. Many patients are so weak after operation that they cannot be put on a restricted diet. Moreover, a quicker means is advisable in some cases. We have hoped to find some drug which can be injected intravenously that would show beneficial clinical and chemical results. At the suggestion of Dr. Charles Lieb, of Columbia University, we have used sodium-thio-sulphate. It has been used empirically, as we do not know its exact chemical action. Dr. Lieb had used this drug to prevent extracorporeal clotting in animal experiments and assured us that it was nontoxic. When injected into animals it causes a very definite decrease in the prothrombin but has very little effect on the fibrinogen. Clinically we have used 10 cubic centimeters of a 10 per cent solution intravenously for 3 successive days, repeating the series after a period of 2 to 3 days' interval if results were unsatisfactory (Table IV).

RESULTS

As we have stated, our results are based on chemical blood examinations before and after treatment and a study of the temperature charts, patients' statements, and a general analysis of cases. We must again sub-divide the patients operated upon into three groups:

1. Patients running irregular postoperative temperatures without signs of peripheral vein lesions but with high clotting factors. In the routine study of cases in which there have been high clotting factors after operation and in which sodium-thio-sulphate has been administered there was a temperature drop, alteration of the blood content, and clinical improvement as voiced by the patient in approximately 50 per cent. In the remainder very little change could be noted save that none of them developed a phlebitis or thrombosis. In order to determine whether or not the routine postoperative administration of sodium-thio-sulphate was of any advantage we have recently taken alternate cases submitted to surgical operation. These patients have been treated exactly alike save that one series was administered sodium-thio-sulphate and the controls were not, irrespective of the operative procedure, postoperative course, or the blood examinations. The series is too small for didactic conclusions, 22 cases having had sodium-thio-sulphate administered and an equal number having been used as controls. It is interesting to note, however, that in 2 of the control cases phlebitis developed and in one a pleurisy while in none of the patients who had sodium-thio-sulphate, did complications develop.

2. Patients with low grade phlebitis without marked elevation of temperature but with definite tender swelling of the limb. It has been our impression in the study of these cases that if treatment is prescribed early in the disease definite improvement is noted, but if the disease is fairly advanced there has been little value derived. Let me cite one example:

A patient in the Presbyterian Hospital had had a left phlebitis followed by two pulmonary emboli. Her symptoms had subsided and she was apparently

improving when she developed evidence of phlebitis in the right thigh. We were called in to see her for the first time on the first day of the latter complication. Her blood clotting factors were high and she was immediately given sodium-thio-sulphate intravenously. Her temperature dropped to normal within 24 hours and her pain and swelling rapidly subsided.

The department of fractures at the Presbyterian Hospital of the Medical Center of Columbia University has utilized our technician in the study of the blood clotting factors in patients suffering from fractures with symptoms suggestive of thrombosis or embolism. Following is the statement of Dr. Clay Ray Murray, associate professor of surgery:

"At the Presbyterian Hospital, the clotting index has suggested an interesting line of investigation as to the cause of death in patients with neck of the femur fractures. These patients die from pulmonary complications which are usually considered hypostatic pneumonias and from cerebral complications which are commonly considered fat embolism, 'delayed shock,' or 'senility aggravated by shock.' The patients with hip fractures who develop these conditions have shown clotting indices of 1.6 to 1.9 and 3 of the cases have completely cleared up where the clotting index was brought down to normal by the use of sodium-thio-sulphate intravenously. In one patient, when the symptoms recurred and the clotting index was again found up to its original level, a second course of sodium-thio-sulphate (bringing the index to normal) resulted in a second clearing up of the symptoms. On the basis of the findings, considerable support had been given to the assumption that the so called pneumonias are really pulmonary thromboses and that the so called fat emboli are really cerebral thromboses or emboli, both of them dependent upon the double factor of raised clotting index and slowed vascular activity due to bed rest. If this be true it may be possible to control the clotting index and so materially influence the mortality in neck of the femur fractures. Definite investigation of the problem is now planned."

3. In patients in whom infection appears to be the predominating factor and in whom phlebitis and periphlebitis are pronounced and there is a chill and rapid rise of temperature, little if any benefit has been derived from the intravenous administration of sodium-thio-sulphate. We have assumed, in this group, that infection is the predominant, and thrombosis the minor, element. Blood studies show some increase in prothrombin and marked increase in fibrinogen. Following the advice of Shallenberger we have used intravenous injections of 0.5 per cent gentian violet solution. Ten patients have been treated by this method. We have seen no ill effects save an occasional chill, and have had a number of patients in whom the immediate drop of temperature, relief from pain, and decrease in swelling (from 1 to 2 inches in the circumference of the thigh) in 2 or 3 days' time, would seem to show beneficial effects.

Three cases of migratory phlebitis have been studied. Under a limited diet they have higher clotting factors than normal, but in this small series we have not seen any benefit from any therapy we have advised.

SUMMARY

Four thousand two hundred and fifty patients have been operated upon since the inauguration of this study. Phlebitis has developed in 11 cases. There has been no death from embolism in cases treated under this routine. During this period there have been 3 deaths from embolism in private patients of members of the staff who have not carried out these principles of treatment.

It is hoped that by further study a more simplified blood test may be found which can be used in a general hospital in the routine examination of patients. As we have been handicapped financially we have not been able to employ a full time biochemist to study some of the more intricate problems of which we are ignorant. We have hopes that we may some time be able to employ one, because the elements which alter clotting factors are not yet definitely known. Freund and others have stated various theoretical substances, but the exact chemistry of these has not yet been proved.

Calcium and phosphorus determinations were made on a small series (33 patients), but the variations from normal were so slight that these examinations were discontinued.

CONCLUSIONS

1. We believe that loose abdominal dressings, early postoperative feeding, and fluid administration relieve postoperative distention and distress and may diminish thrombosis.

2. Blood studies show that certain individuals are more prone to develop thrombosis than others. The blood abnormalities can frequently be improved by diet and intravenous medication.

3. There are probably substances liberated in the blood through the effects of operative and postoperative trauma and infection that tend to change normal into abnormal clotting factors. The elimination of operative and postoperative trauma should diminish this incidence. Routine blood studies frequently show alterations in the clotting factors before the onset of thrombosis and thrombophlebitis. It is our belief that in a number of cases thrombosis and embolism may be aborted by administering a diet low in fats and proteins and the intravenous administration of sodium-thio-sulphate.

4. We are not satisfied that sodium-thio-sulphate is the best method of approaching this problem, but at present it seems to be a definite aid.

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THE TIME OF PERMEATION OF COLORED SOLUTIONS THROUGH THE PLACENTA OF THE WHITE RAT

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THE physiology of the mechanism governing the interchange of substances through the placenta from mother to fetus and from fetus to mother has attracted the attention of numerous investigators since the beginning of scientific medicine and biology. The chief interests lie mainly in three fields of study: first, that concerned with the nutrition and elimination of waste products of the fetus; second, a group dealing with the possible transmission of acquired biological qualities from mother to fetus; and third, that field concerned with the harmful or beneficial interchange of hormones, internal secretions, and toxic products from mother to fetus and vice versa. Although an extensive literature pertaining to the interchange, through the placenta, of substances, both nutrient and biological, has been produced, little is still known of the normal or pathological physiol-

ogy of the placenta. Perhaps the one outstanding fact gathered from an extensive survey of the literature is that no group of investigators has confined its efforts to the study of the normal and pathological physiology of the placentation of one animal. Experiments dealing with the permeability of diverse substances have been made on almost all laboratory animals and the results naturally are conflicting, for there is a difference in the placentation of animals.

In order to arrive at more definite conclusions regarding the physiology of the placenta, an exhaustive study of the placentation of one animal seemed advisable. With this in mind, we have been studying for the past 5 years the physiology of the placentation of the albino rat. Our particular interest has been concerned with the study of the transmission of immunity from mother to offspring while *in utero*. However, we discovered that in many instances we were unable to interpret our negative results because of lack of knowledge of the fundamental physiology of the placenta.

One of the fundamental physiological problems confronting us in the analysis of our results was the normal rate of trasmission of substances to which the placenta is permeable in either direction between fetus and mother. A review of the literature reveals no definite statement concerning this phase of the problem and, therefore, the following experiments were carried out in an attempt to establish some definite rate for the transmission of soluble substances through the placenta of the white rat.

For the study of the rate of permeability, we selected colored solutions, since they would give us a definite and easily read index. We have tried, as have many other investigators, the colloidal dyes that are used for staining, and arrived at the same conclusions as the others, namely, that inert colloidal dyes are not normally transmitted through the placenta. As early as 1867, Jassinsky injected a suspension of carmine into pregnant dogs and, although the animals died from this procedure in about 20 minutes, he observed that the substance did not reach the fetal circulation, but was held in the placenta. Schlect (1907) describes a pregnant mouse which had been stained by the injection of lithium carmine. The dye had failed to stain the fetuses but was plainly visible in the placenta and fetal membranes. Goldman (1909) injected a number of pregnant mice and rats with colloidal solutions of pyrrhol-blue and trypan blue, and in every instance the tissue of the mother became deeply stained, but the fetuses remained unstained. Wislocki (1922) working with trypan blue solutions concluded that foreign colloidal material can not pass from the fetal into the maternal circulation. Yoshitaka Schimidzu (1922) published a comprehensive study on the permeability of the placenta by dyestuffs in the albino rat and the white mouse. In his experiments he employed twenty-three dyes. A solution of each dye was injected hypodermically between the scapulæ and, at varying intervals from 4 to 48 hours after injection, the fetuses were removed by cæsarean section, and the coloration of the maternal and fetal tissues determined by various detection methods. He concluded from his studies that the placentæ of the white rat and mouse are permeable to all the basic dyes and that the power of the dyes to pass through the placenta runs parallel with the colloidal state of their solution in the serum, especially with their ability to spread in a gel of high percentage.

MATERIALS AND METHODS

We considered the dyes used by other investigators not suitable for use in the study of this particular problem, because colloidal dyes, as found by them, do not pass through the placenta and those colloidal dyes of high dispersion that Schimidzu concluded pass the placenta permeate very slowly. Moreover, the more soluble dyes used in their experiments possessed powerful staining qualities which caused the dyes to unite with the tissues. We were interested in finding a soluble dye or group of dyes which would be easily detectable, which would not combine with the tissues, and which could be recovered unchanged chemically from the fetus after injection of the dye into the mother or from the mother after its injection into the fetus. A dye suitable for the needs of our present investigation must have the following characteristics:

1. The dye must have a high degree of solubility.

2. A very small amount of the substance must color a large quantity of fluid or serum.

3. The coloring substance must not react chemically to any great degree with the tissue and thus be taken up by the tissues.

4. It must remain stable, undergoing no chemical change when it is injected into the tissues.

5. It must be non-toxic to the organism.

We experimented with many of the histological dyes, indicators, and coloring materials now on the market, finally choosing three as most suitable for use in our experiments. The first, and most satisfactory, is phenolsulphonephthalein (phenol red), an indicator which is a red solution at a hydrogen-ion concentration of 7.6. The second, cochineal, also an indicator, obtained from the dried fecundated insect, coccus cacti, Linné, is a yellow solution below a hydrogen-ion concentration of 4, changing to a red-brown between 4 and 5 and to lilac at a hydrogen-ion concentration of 5. Cochineal only acts as a powerful dye when a mordant, such as salts of zinc, bismuth, or nickel, is added. The third, saffron, is extracted from the dried stigmas of the crocus sativus. Its solution has an orange or deep yellow color which is not changed by the hydrogen-ion concentration range of body fluids.

Phenolsulphonephthalein, as supplied in ampuls for kidney functional tests, was used in our experiments. Each cubic centimeter of the solution contains 6 milligrams of the dye. In preparing a saturated solution of cochineal, a quantity of the cochineal bugs was ground in a mortar with pestle, distilled water added, the mixture stirred for about 10 minutes, then allowed to stand for several hours, after which time the supernatant fluid was decanted and filtered through filter paper. A saturated solution of saffron was prepared in the same way from the dried stigmas of the crocus plant.

Pregnant white rats, mus norvegicus albinus, selected from the colony of the Department of Anatomy of the University of Pittsburgh were employed. Whenever possible, rats from the sixteenth to twenty-first day of gestation were used.

The method employed in determining the permeability of the placenta and the time of transmission of the colored solutions from fetus to mother conformed with the following general routine. The pregnant animals were anæsthetized by injecting intraperitoneally a 2 per cent solution of sodium amytal, a dosage of 80 milligrams per kilogram of body weight being used. After the rat was in deep anæsthesia, 1 cubic centimeter of the mother's heart blood was drawn, centrifuged, the serum pipetted off, and placed in a Wassermann tube to be used as the control serum. The abdomen of the rat was then opened and the gravid uterine horns were exposed. From 1 to 2 minims of the colored solution were injected, in one group of experiments into the abdominal cavity of each fetus, and in another group into the amniotic sac of each fetus. Usually a total of from 6 to 12 minims of the coloring solution could be injected into the fetuses or amniotic sacs. The injection was made directly through the uterine wall by means of a Luer syringe with a spring attachment and a No. 27 gauge needle. Extreme care was taken not to allow any of the coloring fluid to enter any part of the mother, especially the space between the amniotic sac and the wall of the uterine horn. The time of injection was noted, the injection of the first fetus being taken as the time of injection. An inspection was made of the uterine horns for leakage into the uterine cavity, and then the uterine horns were carefully replaced in the abdominal cavity, and the abdominal wall was closed. One to 2 cubic centimeter samples of mother's heart blood were drawn at various intervals ranging from 1 minute to 4 hours. As a rule, four or five heart punctures can be made without killing the animal. The blood samples were centrifuged, the serum pipetted off into a Wassermann tube and, in the phenolsulphonephthalein and cochineal groups of experiments, a few drops of 1 per cent sodium hydroxide was added to all sera including the controls. On a white background and in the daylight, when possible, the color of the control serum, taken before the injection of the coloring fluids into the fetus, was compared with the color of the sera taken after injection. Urine from the bladder was obtained after death of the ani-

mal. In the phenolsulphonephthalein and cochineal experiments, equal parts of the urine were placed in two Wassermann tubes and a few drops of 1 per cent sodium hydroxide were added to one tube and the color compared with the color of the other tube. Samples of urine which were used in the saffron experiments were taken but gave no conclusive results because of the yellow color of both saffron and urine.

Only phenolsulphonephthalein was used in testing the passage of coloring solution from mother to fetus. In this series of experiments the mothers were anæsthetized with amytal and injected intravenously (femoral vein) with 2 cubic centimeters of 0.6 per cent phenolsulphonephthalein solution. At definite times, ranging from 15 minutes to 2 hours after the initial injection, all the fetuses were removed from the various injected animals; thus, at the end of 15 minutes all the fetuses were removed from the first animal, at 35 minutes from the second animal, and so on until 2 hours had elapsed. The fetuses were stripped of their amniotic sacs and washed in normal saline, then cut into pieces, placed in a large centrifuge tube, and centrifuged for 30 minutes. The supernatant serum was pipetted off, divided into equal parts, and placed in two Wassermann tubes. To one part was added a few drops of 1 per cent sodium hydroxide and the color was then compared with that of the other part. The amniotic fluid and the normal saline in which the fetuses had been washed were also tested for the presence of the dye by the addition of 1 per cent sodium hydroxide.

The placentæ from these fetuses were separated from their maternal attachments. They were not washed and the maternal blood that collects on the placenta in its detachment from the wall of the uterine horn was not removed. The placentæ were cut into small pieces and centrifuged with a small amount of isotonic sodium citrate solution. The supernatant fluid was pipetted off and tested in the same way for phenolsulphonephthalein. Sodium hydroxide was also dropped on pieces of placenta, placental site in the uterine horn wall, and on the cut fetus, and color changes looked for in the various tissues.

EXPERIMENTS

The experiments consisted of three groups: (I) the determination of the rate of passage through the placenta of colored solutions from fetus to mother; (II) experiments to ascertain the rate of passage through the placenta of colored solutions from the amniotic sac of the fetus to the mother; and (III) the analysis of the permeability of the placenta to soluble dyes injected into the mother.

Control experiments were first made with phenolsulphonephthalein, cochineal, and saffron to determine the minimal amount of dye necessary to give a definite color reaction to the mother's serum, detectable by our gross methods. In these experiments, 1 minim of the dye injected into the femoral vein of the rat gave a definite color change to the serum taken from the animal after 5 minutes; serum obtained from the animal before injection being used as a control. As the control experiments demonstrated that 1 minim of each of the coloring solutions selected was sufficient to give a definite color to all the serum in the animal, it was evident that the total of 6 to 12 minims that were being injected into the fetuses was sufficient to give a definite color test in the serum of the mother, if but a small proportion passed through the placenta.

The results of the passage of the dyes from fetus to mother are tabulated in Table I. In the case of each of the three dyes, a definite color change was noted in the serum of the mother. Ten experiments (Table I, Experiments 1 to 10) with phenolsulphonephthalein were made. The dye was detected in the mother's serum 5 minutes after injection into the fetuses (except in one instance), increasing in intensity up to 3 to 4 hours after injection and then gradually fading away. The urine of these animals showed a positive reaction from 10 to 20 minutes after injection. Five experiments were made using cochineal injections (Table I, Experiments 11 through 15). The dye was first demonstrable in the serum of the mother 10 to 15 minutes after injection of the dye into the fetuses. In 4 experiments (Table I, Experiments 16 through 19), saffron was injected into the fetuses and mother's serum usually took on the saffron color within 10 to 20 minutes after injection.

TABLE I.—INJECTION OF DYE INTO ABDOMINAL CAVITIES

Injection of Dye Solutions into Abdominal Cavities of Fetuses and Testing for Dye in Serum of the Mother.

No.	Dye injected	Amount minims	No. of fetuses injected	Age of fetuses (days)	Mothers' serum	Urine
1	Phenol-sulphone-phthalein	12	6	20	5 min.+++ 280 min.+++	Not tested
2	Phenol-sulphone-phthalein	12	9	15	5 min.+++ 260 min.+++	Not tested
3	Phenol-sulphone-phthalein	6	6	18	5 min.+ 145 min.+++ 210 min.++	Not tested
4	Phenol-sulphone-phthalein	8	8	20	5 min.+ 20 min.++ 60 min.+++ 90 min.++ 120 min.—	2 hrs. positive
5	Phenol-sulphone-phthalein	8	6	20	5 min.+ 60 min.+	Not tested
6	Phenol-sulphone-phthalein	14	9	20	5 min.+ 30 min.++ 45 min.+++ 75 min.++++ 115 min.+++ 135 min.+++	45 min. positive
7	Phenol-sulphone-phthalein	12	7	15	5 min.+ 15 min.+ 25 min.++ 48 min.+++ 67 min.++++ 82 min.+++++ 105 min.++++ 137 min.+++ 152 min.+++	Not tested
8	Phenol-sulphone-phthalein	12	8	15	5 min.— 10 min.+ 20 min.+ 38 min.++ 55 min.+++ 75 min.++ 95 min.++	95 min. positive
9	Phenol-sulphone-phthalein	12	8	18	5 min.+	Not tested
10	Phenol-sulphone-phthalein	10	6	19	5 min.+	Not tested
11	Cochineal	12	6	16	5 min.+	Not tested
12	Cochineal	12	8	18	10 min.+	Not tested
13	Cochineal	12	4	20	15 min.+	Not tested
14	Cochineal	12	8	19	10 min.+	Not tested
15	Cochineal	10	8	20	10 min.+	Not tested
16	Saffron	12	10	19	20 min.+	Not tested
17	Saffron	12	10	16	5 min.+	Not tested

TABLE I.—Continued

No.	Dye injected	Amount minims	No. of fetuses injected	Age of fetuses (days)	Mother' serum	Urine
18	Saffron	12	9	18	10 min.+	Not tested
19	Saffron	12	8	18	20 min.+	Not tested
20	Phenol-sulphone-phthalein	2	1	20	5 min.— 30 min.— 60 min.— 120 min.—	120 min. positive
21	Phenol-sulphone-phthalein	2	1	19	5 min.— 30 min.— 60 min.—	60 min. positive
22	Phenol-sulphone-phthalein	2	1	18	5 min.— 30 min.— 60 min.—	60 min. positive
23	Phenol-sulphone-phthalein	2	1	20	5 min.— 30 min.— 60 min.— 120 min.—	120 min. positive

Five experiments were made in which phenolsulphonephthalein was injected into the amniotic sacs of the fetuses. The results of these experiments are tabulated in Table II. The first positive test appears usually from within 30 minutes to 1 hour. Thus it takes from six to twelve times as long for the dye to pass from the amniotic sac through the placenta as it does when the dye is injected into the abdominal cavity of the fetus.

In the third group of experiments, phenolsulphonephthalein was injected into the blood stream of pregnant rats and sought for in the fetuses. In no instance in the five experiments (Table III) was the dye recovered from the fetal tissues or the fluid in the amniotic sac. The supernatant sera of the centrifuged macerated fetuses did not change color when a solution of 1 per cent sodium hydroxide was added. Likewise, amniotic fluid or normal saline in which fetuses were washed did not show any of the dye. However, when sodium hydroxide was added to the supernatant sera of the unwashed macerated placentæ, the color of the sera changed to a deep red. When pieces of the placentæ and the uterine horn tissue about the placental sites were tested by dropping sodium hydroxide on them, these tissues turned a deep red or violet. The tests on the supernatant sera obtained from the macerated placentæ, placental and uterine tis-

TABLE II.—PHENOLSULPHONEPHTHALEIN INTO AMNIOTIC SACS

Injection of Phenolsulphonephthalein into the Amniotic Sacs of Fetuses and Testing for the Dye in the Serum of the Mother

No.	Dye injected	Amount, minims	No. of amniotic sacs injected	Age of fetuses (days)	Mother's serum	Urine
24	Phenolsulphonephthalein	6	6	20	10 min.—negative 60 min.—slightly positive 90 min.—slightly positive	90 min.—positive
25	Phenolsulphonephthalein	6	7	10	15 min.—negative 30 min.—negative 65 min.—negative 105 min.—negative	105 min.—very positive
26	Phenolsulphonephthalein	12	8	20	30 min.—very slightly positive 60 min.—very slightly positive 95 min.—slightly positive 120 min.—positive	Not taken
27	Phenolsulphonephthalein	12	8	10	30 min.—very slightly positive 60 min.—positive 90 min.—slightly positive	Not taken
28	Phenolsulphonephthalein	12	12	15	30 min.—very positive 90 min.—very positive	Not taken

TABLE III.—INJECTION OF PHENOLSULPHONEPHTHALEIN INTO MOTHER'S FEMORAL VEIN

Injection of 2 Cubic Centimeters of 0.6 Per Cent Phenolsulphonephthalein into Femoral Vein of Mother and Testing for the Dye in Placenta, Fetal Tissues, and Amniotic Fluid

No.	Dye injected	Amount c.cm.	Time of test after injection of dye	No. of fetuses macerated	Approximate age of fetuses	Serum from macerated fetuses	Addition of NaOH to fetal tissues	Amniotic fluid	Serum from macerated placenta	Addition of NaOH to placental tissue	NaOH on placental site and uterine tissue	Mother's heart blood
29	Phenol-sulphonephthalein	2	¼ hr.	4	18	Negative for dye	No color change	Negative for dye	Very positive for dye	Pink-red color change	Pink-red color change	Positive for dye
30	Phenol-sulphonephthalein	2	½ hr.	4	19	Negative for dye	No color change	Negative for dye	Very positive for dye	Pink-red color change	Pink-red color change	Positive for dye
31	Phenol-sulphonephthalein	2	¾ hr.	4	20	Negative for dye	No color change	Negative for dye	Very positive for dye	Pink-red color change	Pink-red color change	Positive for dye
32	Phenol-sulphonephthalein	2	1 hr.	4	18	Negative for dye	No color change	Negative for dye	Very positive for dye	Pink-red color change	Pink-red color change	Positive for dye
33	Phenol-sulphonephthalein	2	2 hrs.	4	19	Negative for dye	No color change	Negative for dye	Very positive for dye	Pink-red color change	Pink-red color change	Positive for dye

sue were positive 5 minutes after the injection of phenolsulphonephthalein into the mother, and evidence of the dye could be found in the placentæ and uterine tissue as long as the serum of the mother remained positive. Thus, although the dye was found in the placentæ and circulating through the uterine tissues about the placental sites, no evidence of it was found in the fetal tissues or amniotic fluid.

DISCUSSION

It was hoped, originally, to study the rate of transmission of colored solutions through the placenta not only from the fetal tissues and the amniotic sac to the mother but also from the mother to the fetus. The results of the experiments failed to show transmission of phenolsulphonephthalein from mother to fetus; therefore, this phase of the problem is still unsolved. On the other hand, the dyes readily passed from the fetal tissues to the maternal circulation.

After the injection of phenolsulphonephthalein into the fetus large quantities of the dye were found in the maternal circulation in 5 minutes; cochineal was recovered in large quantities within an average of 10 minutes; and, saffron within an average of 15 minutes.

Thus all the dyes were rapidly absorbed and eliminated from the fetal tissues through the placenta into the maternal circulation.

When phenolsulphonephthalein was injected into the amniotic sac, the dye was found in large quantities in the maternal circulation between thirty minutes and one hour. Thus it took the dye six to twelve times longer to pass from the amniotic sac to the circulation of the mother than from the fetus to the mother. The mode of absorption and transmission of substances from the amniotic sac to the maternal circulation has not been satisfactorily worked out in the rat. However, Wislocki (1920) studied the absorption of trypan blue injected into the amniotic cavity of the guinea pig and cat, and concluded that this substance is absorbed during the latter half of pregnancy; the absorption occurring in three ways: (a) through the gastro-intestinal tract; (b) through the respiratory tract; and, (c) by diffusion through the amniotic membranes. Observations on the absorption of sodium amytal from the amniotic sac of the rat fetus have been previously reported by us (Boucek and Renton, 1931). It was found that this anæsthetic injected either into the amniotic sac or the fetus caused anæsthesia of the mother. The time of absorption and transmission of this substance from the amniotic sac was much slower than from fetal tissue. This observation is in accord with the present experimental results.

The time of transmission from fetus to mother in these experiments includes three factors: first, the rate of absorption of the dye; second, its transmission through the placenta; and, third, the time required for enough dye to accumulate in the blood of the mother to overbalance its excretion by the kidneys and give a sharp test. Since the time of transmission of the dye through the placenta was our chief interest, it seemed advisable to reduce the 2 other factors to a minimum. The first was to a great measure eliminated by using dyes that are quickly absorbed and do not readily stain or react with the tissues. The third factor was reduced in importance by injecting many fetuses or amniotic sacs and thus producing a larger transmission surface and furthermore, a larger absorption surface. This fact was made clear to us during the first experiments carried out in which only a single fetus was injected with 2 millimeters of the dye (Table I, Experiments 20 through 24). In no instance could the dye be demonstrated in the heart's blood, although it was recovered in large quantities from the urine. Evidently, the amount that was being poured into the blood stream of the mother was not sufficient at any time to overbalance the elimination by the kidneys. When, however, a number of fetuses or amnia were injected, positive tests were obtained in the blood. With these two factors reduced to a minimum, the observed time of transmission of the dyes may be taken as a close approximation of the actual time of transmission.

These experiments give no evidence concerning the time of transmission of soluble substances from the mother to the fetus, since phenolsulphonephthalein was not found in the fetus or in the amniotic sac after injection of large quantities of the dye into the mother. The macerated unwashed placentæ, however, contained large quantities of the dye as did also the uterine tissues and blood. The presence of large quantities of the dye in the placenta and in the tissues of the uterine wall and the absence of it in the fetus leads us to conclude that phenolsulphonephthalein does not pass in measurable quantities from mother to fetus under these experimental conditions.

There are many factors that might be involved in producing the positive results of the permeation of the placenta by the dye from fetus to mother and the negative results of the failure of the dye to permeate the placenta from mother to fetus. Those to be considered are chiefly: (a) the concentration of the dye in the fetal blood circulating through the placenta after its injection into the fetus as compared with the concentration in the maternal blood reaching the placenta following the injection into the mother; (b) the circulatory balance between the amount of fetal blood passing through the placenta and the amount of maternal blood that comes in contact with the placenta; and, (c) the ability of the placenta to allow the dye to pass in one direction and prevent it from passing in the other direction.

The concentration of the dye in the fetal and the maternal bloods, must be somewhere near equal since in the former case, 2 minims of the dye was injected while in the latter 2 cubic centimeters of the dye was injected. Since there is no experimental evidence available concerning the ratio of the volume of fetal blood that passes through the placenta to the volume of maternal blood that bathes the villi, the rôle that the circulatory balance plays in our results is a moot question. The theory of a selective permeability of the placenta has been denied by many investigators. However, it is difficult not to take it into consideration in the light of our experimental findings and the numerous clinical observations of the difference in the concentrations of substances in the maternal and fetal bloods. One of the most frequent examples of this is that in pregnant women with diabetes, although the blood sugar of the mother is very high, the cord blood is within normal limits. Schlect (1907) goes so far as to say that he believes that one of the chief functions of the chorionic cells is to protect the fetus from toxic substances which may be present in the maternal blood stream.

Our work does not give any definite proof of a selective activity governing the interchange of substances through the placenta. However, as our work progresses and as we obtain more evidence regarding the reaction of the placenta to substances injected into the fetus and mother, we are accumulating evidence confirming the opinion that the placenta is not a semi-permeable membrane subject only to the laws of osmosis, diffusion, and permeability, but that it reacts to vital factors concerned with the nutritional and excretory needs of the fetus and the physiological balance between the factors concerned with the maintenance of a normal functional activity of the maternal and fetal organisms.

CONCLUSIONS

1. Phenolsulphonephthalein, cochineal, and saffron when injected into the fetus or amniotic sac are readily absorbed and pass through the placenta into the circulation of the mother.

2. The time of absorption and transmission of phenolsulphonephthalein from the fetus through the placenta in large enough quantities to be detected in the serum of the mother is 5 minutes; for cochineal 10 to 15 minutes; and saffron 10 to 20 minutes.

3. The time of absorption and transmission of phenolsulphonephthalein from the amniotic sac through the placenta in sufficient quantity to be detected in the serum of the mother is within 30 minutes to 1 hour or six to twelve times slower than when phenolsulphonephthalein is injected into the fetal cavities or tissues.

4. Phenolsulphonephthalein was not recovered from fetal tissues after injection of large quantities of the dye into the circulation of the mother although large amounts of the dye were recovered from the placentæ.

We wish to express our appreciation to Dr. Davenport Hooker and Dr. John Donaldson, Department of Anatomy, University of Pittsburgh, and to Dr. Robert Tennant, Jr., Department of Pathology, Yale University, for helpful suggestions during the progress of this work.

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CLINICAL SURGERY

FROM THE MEMORIAL HOSPITAL, NEW YORK

CHEILOPLASTY FOR ADVANCED CARCINOMA OF THE LIP[1]

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SURGICAL excision as the primary treatment for carcinoma of the lip has been largely replaced by irradiation therapy. The average growth of the lower lip is most satisfactorily treated by irradiation which, in competent hands, will result in practically 100 per cent cures of the local lesion. Metastasis to the neck is, of course, an entirely separate problem under any method of treatment. The cosmetic result, even after heavy irradiation, is excellent. There is little or no scarring and the contour of the lip remains unchanged, unless there has been replacement *en masse* of normal by neoplastic tissue.

Although surgery has no longer a place in the treatment of the small or moderately sized lesion, extensive surgical excision of the lower lip with plastic closure must be resorted to in the bulky, fungating, and infected tumors which sometimes occur in the neglected case. The growth may involve the entire thickness of the lip and extend down into the subcutaneous tissues over the symphysis mentis. Massive local recurrences, after incomplete surgical excision or the recurrences in devitalized tissue following repeated inadequate irradiation, may, likewise, call for extensive local removal. The operation to be described is a method of construction of an entire new lower lip and chin. It is a modification of an operation first described by Camille Bernard, in 1853. This operation permits a wide removal and furnishes a functionally satisfactory new lower lip and leaves a minimum of visible scarring.

A surgical procedure of the extent described is not justified in the presence of large, multiple, or bilateral metastases. The operation should be cautiously proposed, even in the presence of a single small metastasis for which, in any case, the surgeon must assume the responsiblity for adequate removal. The operative exposure will permit a limited removal of gland-bearing tissue from the submental and submaxillary regions, but no extensive neck dissections can be carried out during this operation. If a limited bilateral neck dissection or a block dissection of one side is indicated, the disease is probably too far advanced and malignant to be successfully dealt with by surgery alone. The operation here described is best suited to the bulky, fungating types of growth in which metastases are quite commonly absent.

HISTORICAL NOTE

The origins of cheiloplasty for cancer of the lower lip are lost in antiquity. Celsus (born about 25 B.C.) described the V-shaped incision, as well as modifications to include horizontal incisions from the angles of the mouth and also horizontal incisions along the lower edge of the mandible so as to form two lateral flaps of the cheeks. Operations of this type are often referred to as the methods of Celsus.

Most of the classical methods now described in surgical texts were devised during the first half of the 19th century. Von Bruns, in 1859, described 32 methods by 52 authors. The general principles of the method described in the present report were first published by Camille Bernard, in 1853. The principles of this operation are usually credited to Burow, whose methods for the plastic closure of defects by the excision of adjacent triangles were published by his associate Saemann, in 1853. The triangular flap method of Burow, however, necessitates a V-shaped excision of the lower lip and (for reasons to be discussed) the operation has a limited range of application; mainly to the smaller lesions of the lip.

The excision of a rectangular or square segment of the lower lip, the formation of two lateral cheek flaps mobilized from the mandible, the excision of full thickness triangles above and lateral to the angles of the mouth, and the conservation of the mucosa of these triangles to form the vermilion border of the new lower lip were

[1]From the Department of Head and Neck Surgery. Service of Dr. Douglas Quick.

all first described by Bernard, in 1853. Later references to his report seem to be based on a gross misinterpretation. Desgranges, a few months later, discusses Bernard's operation as being poorly devised since (according to Desgranges) the triangles were excised from the upper lip itself with the result that the upper lip was thereby shortened and the mouth narrowed. Bernard's report seems perfectly plain, in that he did excise the triangles above and lateral to the angles of the mouth and conserved the mucosal surfaces attached at the bases to be reflected forward and sutured so as to form the vermilion border of a new lower lip. Blair and others erroneously credit Stewart with devising the latter modification in 1910.

GENERAL PRINCIPLES OF INFERIOR CHEILOPLASTY

Many of the classical methods suited only to the smaller lesions of the lower lip have been rendered superfluous by irradiation therapy, especially during recent years when proper dosage and better technique, based upon a better understanding of the physical principles of radiation have given such eminently satisfactory results, both from the curative and cosmetic standpoints. We are of the opinion that the simple V-shaped operation should never be used as the primary treatment. It is suited only to the very early small lesions, and in any case is followed by more deformity and scarring than is irradiation. In massive neglected growths, where much normal tissue has been destroyed by replacement with tumor tissue, destruction of the disease by irradiation and later repair by plastic surgery is the safest procedure. Those opposed to irradiation will overemphasize the difficulty of plastic surgery in irradiated tissue. In our experience, the obstacle is not a serious one, provided the surgeon himself handles the case from beginning to end, and plans the irradiation and subsequent surgery so that the maximum benefit is derived from each agent. The radiotherapeutist and the surgeon should be one and the same person and each separate procedure should be planned with a view to the entire problem, which includes the care of possible subsequent metastases to the neck. A procedure such as the one described is suited to excision and repair of large defects and is not intended for the repair of the lesser defects following irradiation.

In our opinion inferior cheiloplasty should always be done by the use of full thickness flaps of cheek or lip. Methods utilizing flaps of skin from the neck are more subject to failure and in cases involving the lower lip will give much less satisfactory functional and cosmetic results. The same is true of defects of the upper lip and anterior portions of the cheek. Large defects involving the posterior portions of the cheeks may require a combination of methods. In any form of cheiloplasty or meloplasty, the oral surface of the repair should be lined by epithelial tissue. A raw surface within the mouth will subsequently heal by scarring and contracture, ending in a partial cosmetic and functional failure. The ideal oral lining is obviously mucosa, and the use of skin for the inner surface necessitates either two flaps or the doubling of a skin flap, and the chances of failure are thereby increased.

In inferior cheiloplasty the advantages of cheek flaps with their mucosal lining are of extreme importance. The new lower lip must provide for an adequate gingivobuccal gutter, otherwise, drooling of saliva will result. The normal lower lip is very loose and flexible, and is maintained in position by the combined action of the orbicularis, the risorious, and zygomaticus. After wide excision, the new lower lip, if it is to escape sagging and gradual contracture downward, must be more taut in the horizontal plane, since it will be less supported by the horizontal cheek muscles and not at all by the orbicularis. It will be readily understood that these principles are followed if the new lower lip is constructed from the cheeks, but that sagging and contracture are bound to follow a doubled skin flap from the neck.

Although the lower lip is quite elastic, cheiloplasty, after excision of as much as one-half of the vermilion border, is followed by a shortened lower lip and a redundant overhanging upper lip. Excision of triangles above and lateral to the labial commissures permits the correction of this deformity and the lengthening of the lower lip. The conservation of the mucosal surface of these flaps attached inferiorly and their suture to the raw surface of the new lower lip will form a new vermilion border (Fig. 2).

The operative procedure must be somewhat modified if the involvement of the lower lip is markedly to one or the other side, but in the average case it is advisable to attempt the same extent and form of procedure on either side, so that the two sides of the face appear uniform when viewed from the front. Following a plastic of this extent, the appearance of the face is, of course, altered, but this is less noticeable if the two sides of the face are uniform in appearance.

The incisions from the vermilion border of the lower lip on either side of the growth should, in the average case, run vertically to the lower edge

of the mandible (Figs. 1, 2, and 3). If, due to a wide extent of the growth, they must begin lateral to the labial commissures, the incisions may be inclined mesially to a slight extent. These vertical incisions from the vermilion border down to the lower edge of the mandible form the free ends of the two cheek flaps (Fig. 1, *A B* and *a′ b′*). From the lower edge of the mandible the incisions should continue directly backward in the sagittal plane, so that when viewed from the front, each incision from the vermilion border down on to the neck is a straight line. Viewed from the side, the incisions appear to curve obliquely backward from the lower edge of the mandible (Fig. 1). Below the lower border of the mandible the incisions form the lower edges of the cheek flaps. Their lengths will depend on the amount of mobilization required.

The direction of the incisions below the edge of the mandible is of extreme importance. Illustrations usually show such incisions as following the course of the lower edge of the mandible which is not horizontal, but inclined upward posteriorly. A plane parallel to the lower edge of the mandible will meet a horizontal plane through the labial commissures at about the angle of the jaw. A flap cut with its lower edge along the lower mandibular border will, therefore, be too narrow and taper toward its base, which is in violation of all plastic principles. Furthermore, this portion of the healed scar is almost invisible in the submaxillary and submental regions and is much foreshortened by the apposition of the flaps in the midline.

Near the close of the operation, when the commissures are being repaired, it will be found that the portion of the cheek which forms the new commissure is of too great thickness. This lesser difficulty can be solved by the excision of a portion of muscle and fat.

The hygienic condition of the oral cavity should be attended to before operation. Any markedly carious or loose teeth should be extracted and if pyorrhœa is present, the teeth should be gently scaled by the dentist. However, gross trauma to the gum margins by wholesale extraction of teeth or too energetic treatment of pyorrhœa is to be avoided. Such measures defeat their purpose by substituting an acute inflammatory condition in place of a chronic one. The best cosmetic results are obtained when both upper and lower incisors and cuspids are preserved. Just before going to the operating room, the patient is given a few cubic centimeters of full strength Dakin's solution which he is told to hold in his mouth for 2 or 3 minutes.

TECHNIQUE

The most satisfactory anæsthetic for this type of operation is conduction anæsthesia, the technique of which is not difficult to master and is clearly described by Labat. Two per cent novocain block of both third divisions of the fifth cranial nerves and of both infra-orbital nerves will anæsthetize all of the operative field, except, to some extent, the rather limited incisions below the lower borders of the mandibles, where local infiltration is sufficient. Conduction anæsthesia is quite satisfactory and avoids the postoperative complications of a general anæsthetic. It permits the patient to assist in expelling blood or clots from the oral cavity which prevents their aspiration into the trachea. The patient is also able to follow directions in opening or closing the mouth as necessitated by the various steps of the procedure.

The operation is begun by two incisions which are made from the free border of the lip downward to the lower border of the mandible (Fig. 1 *A B* and *a′ b′*). These incisions should be at least 1 centimeter lateral to any visible or palpable evidence of disease. If an assistant compresses the full thickness of the lip with thumb and forefinger, hæmorrhage is only moderate. A third incision is next made in the bottom of the gingivobuccal gutter and the dissection is rapidly carried down, thus freeing the tissues from the mandible anteriorly, removing periosteum, if there is any question of deep invasion. When the dissection has reached the lower border of the mandible, the flap thus formed is excised by a horizontal incision (Figs. 1 *B b′* and 3). The skin of the submental region is left to be adjusted to fit the closure in the final stages of the operation.

Next, the two horizontal incisions are continued directly backward as viewed from the sagittal plane for about 3 to 4 centimeters (Figs. 1 *B C* and *b′ c′*, 2, and 4). They outline the lower edges of the two lateral plastic flaps. Mobilization of these lateral flaps necessitates next, the incision of the mucosa in each lower gingivobuccal gutter (Figs. 4 and 5). These mucosal incisions are carried back to or beyond the last lower molars, or even up along the anterior borders of the ascending rami. The lateral flaps are then freed from the outer surfaces of the horizontal rami by sharp dissection close to the bone through the muscular attachments as far back as the anterior edges of the masseters. The flaps should then be stretched forward to see if they will meet in the midline without undue tension, and if not, the masseteric insertions into the mandible may be detached by a periosteal elevator. Good technique demands

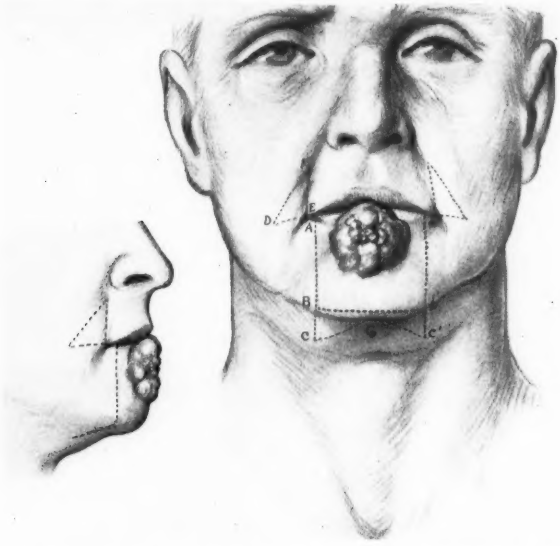

Fig. 1. The incisions *A B* and *a' b'* from the vermilion border of the lip should be placed at least 1 centimeter beyond any visible or palpable evidence of the disease. The rectangle *A B b' a'* outlines the first mass of tissue excised. The flap *B b' C c'* is left attached until the end of the operation when it is trimmed to fit the triangular defect which remains in the submental region. Note that the incisions *A C* and *a' c'* appear as straight lines when viewed from the front but curved posteriorly when viewed from the side.

care at this point to avoid severance of the facial vessels, but ligature of the facial artery seems to have no marked effect on healing. I have twice accidentally severed the facial artery and observed no impairment in the nutrition of the flap.

The next step is to excise triangles of tissue above and lateral to the labial commissures (Figs. 1 *D, E, F,* 2, and 5). These triangles should both first be outlined on the skin by very superficial incisions so as to assure their identical size and position. The mesial side of each should follow quite closely the direction of the nasolabial groove, for the subsequent scar is less noticeable if it falls within this natural fold (Fig. 6). The mesial side of the triangle is thus inclined slightly mesially and is shorter (2 centimeters) than the lateral incision (2.5 centimeters). The base of the triangle is horizontal and in line with the commissure. Its length (2 to 2.5 centimeters) will vary with the amount of lower lip sacrificed. As these triangles are excised, the mucosa is left attached to the base and later turned forward, trimmed, and sutured to form the vermilion border of the new lower lip (Figs. 2, 5, and 6).

Fig. 2. Diagrammatic representation of all tissue excised during the operation. On the right the mucous surface of the Bernard's triangle is shown attached at its base ready to be trimmed to form a new vermilion border. On the left this has already been done.

Fig. 3. The defect left after excision of the rectangular segment comprising almost the entire lower lip and chin. Case P.A., the same as shown in Figure 8. Horizontal incisions have not as yet been extended below the lower border of the mandible.

Fig. 4. Case P. A., the same as shown in Figure 8. Mobilization of the lateral flaps. The vertical incisions have been extended below the lower border of the mandible. The mucosa in the lower gingivobuccal gutters has been incised back to the ascending rami. The flaps have been freed from their attachments to the mandible and are shown retracted.

Closure is begun by suture of the incisions in the lower gingivobuccal gutters. The first stitch is placed entirely on the gingival side at the posterior limit of the incision (Fig. 5). Subsequent sutures are placed about one-half centimeter more anterior on the gingival than on the buccal side and as each is tied, the mucosa is stretched more

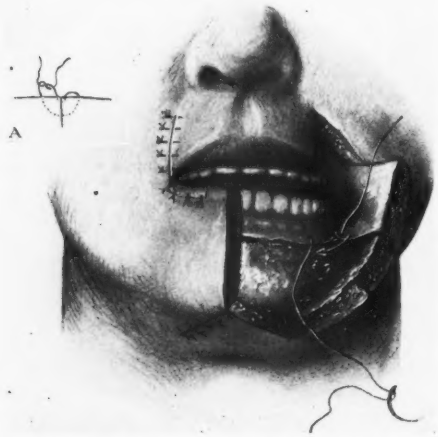

Fig. 5. A schematic representation of complete closure on the right side and beginning closure of the mucous membrane in the gingivobuccal gutter on the left.

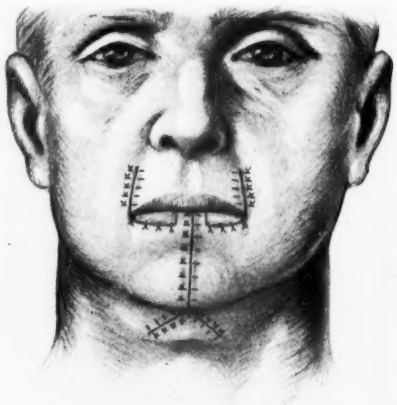

Fig. 6. Closure complete. Note the inverted Y appearance of closure in the submental region where the scar is least visible.

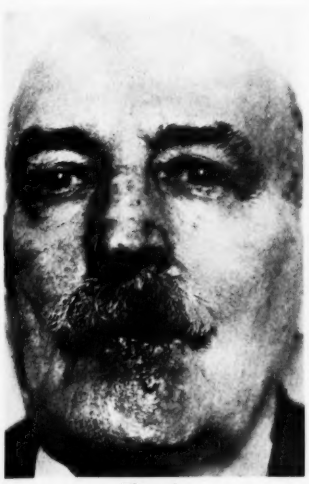

Fig. 7A.

Fig. 7B.

Fig. 7C.

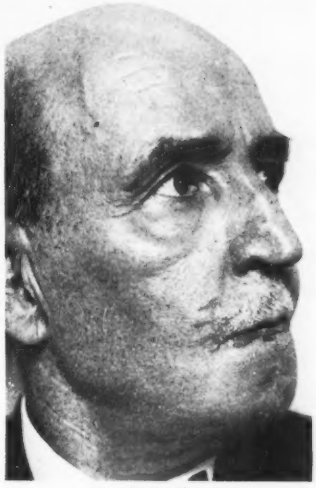

Fig. 7D.

Fig. 7. Case J. R. Deeply infiltrating squamous carcinoma of the lip without metastasis. The disease extends from the vermilion border of the lip almost to the point of the chin. A, Condition before operation; B, 24 hours after the operation (July 27, 1928); C and D, condition 1 month after operation. This patient lived for 3 years without any evidence of recurrence, and died of other causes.

Fig. 8. Case P. A. Deeply infiltrating carcinoma of the lip presenting chiefly on the inner surface and extending down into the gingivobuccal gutter. There were no metastases. A, Condition before operation; B, 24 hours after operation (October 8, 1928); C, 6 months after operation. This patient is living and free of disease, 4 years after operation.

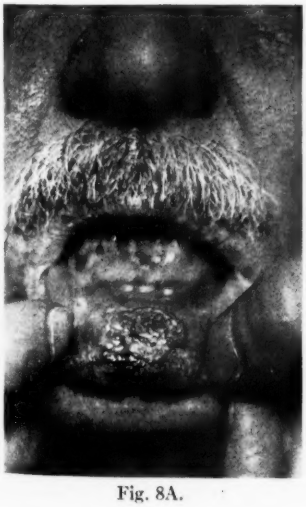

Fig. 8A.

Fig. 8B.

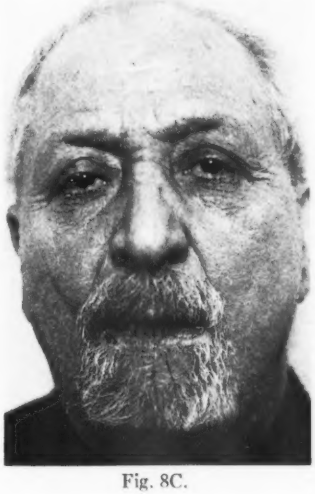

Fig. 8C.

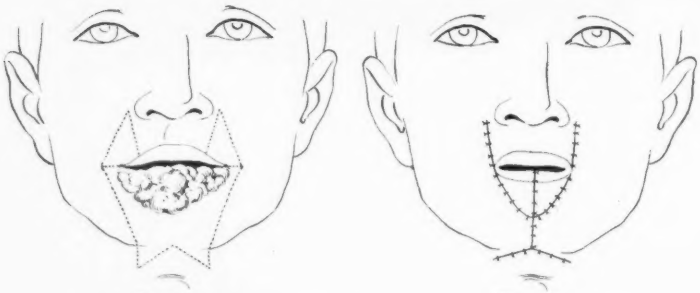

Fig. 9A. Fig. 9B.

Fig. 9. A modified plan of operation for carcinoma of the lip extending to or beyond the commissures utilizing 2 Estlander flaps more mesially placed to help close the necessarily wide defect. The mouth is thereby much narrowed and a second plastic should be done to widen it.

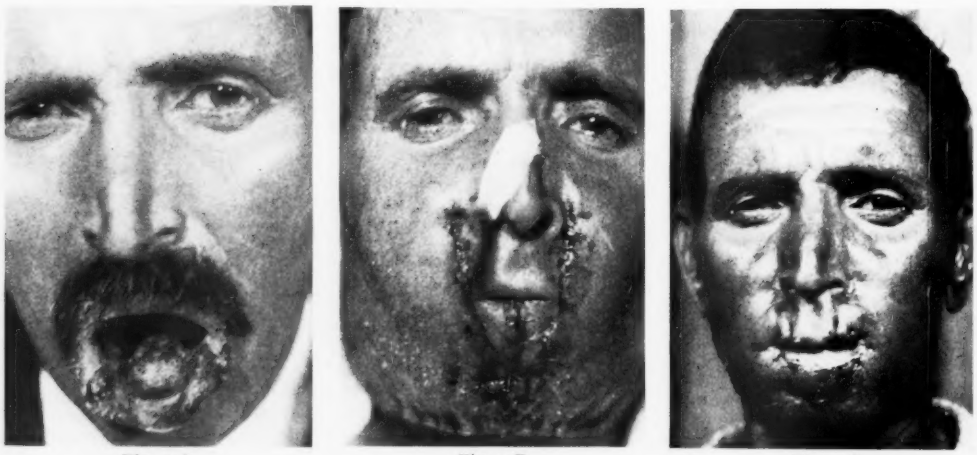

Fig. 10A. Fig. 10B. Fig. 10C.

Fig. 10. Case A. B. A, Bulky carcinoma of the lip extending a little beyond both labial commissures. There were no metastases. B, Twenty-four hours after operation showing the use of 2 Estlander flaps (April 16, 1930); C, after second plastic to widen the mouth. This patient died 6 months after operation of other causes. There was no recurrence of the disease at the time of death.

and more anteriorly, so that eventually its tip will reach the midline. Great care must be taken that the mucosa does reach the midline anteriorly, as any raw surface within the mouth spells failure from the standpoint of a perfect result. After suture of the mucosa to about the position of the cuspid tooth, the mucosal side of the triangle should be sutured, after which the closure of the opposite side is brought to the same stage of completion (Fig. 5). Suture of the flaps in the anterior gingivobuccal gutter is next done, continuing up the midline and over the free border of the lip along the skin edges to the point of the chin. The vertical wounds above the commissures are then closed and mucosal flaps from the triangles trimmed and sutured over the raw surfaces of the new lower lip. In adjusting the angles of the mouth a more natural appearance of the commissures is obtained, if the thickness of the cheeks is lessened at this point by the excision of a wedge of muscle and fat.

The last stage of the operation is the adjustment of the submental skin flap which will be found to be excessive following the drawing forward of the lateral flaps. The skin and superficial tissues are trimmed in the form of an inverted Y

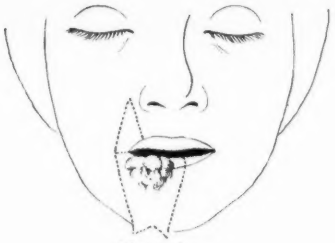

Fig. 11A.

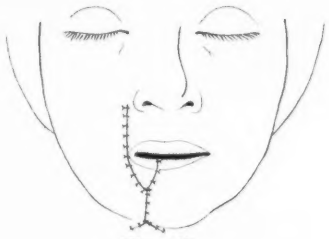

Fig. 11B.

Fig. 11. A modified operation for carcinoma of one-half of the lower lip invading one commissure. One Estlander triangle is brought down to help fill the defect. The narrowed mouth on one side may be corrected by a later plastic.

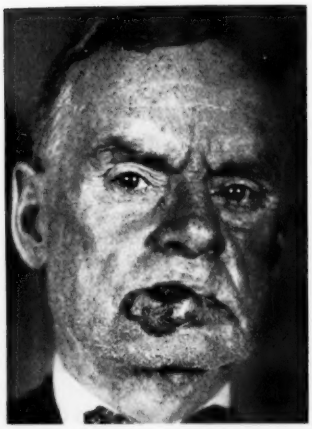

Fig. 12A.

Fig. 12B.

Fig. 12C.

Fig. 12. Case L. D. A, Carcinoma of the lower lip invading a little more than one-half of the right side and extending beyond the right commissure. There were no metastases. B, Twenty-four hours after operation (February 18, 1931). One Estlander triangle has been brought down to help fill the defect which is partly closed by sliding a flap from the left. C, Healed condition. This patient is living and free of any sign of recurrence about 1 year after operation.

and will fall smoothly into place (Figs. 6, 7B, and 8B).

Sutures of medium dermal are most satisfactory and may be used throughout, although the heavy size may be of advantage in cases in which extra tension is required, and the fine for very superficial approximation. This suture material combines strength and flexibility to a marked degree. The eversion stitch (sometimes called the inverted mattress stitch) should be used if the skin or mucosa tend to invert (Fig. 5 *A*). As in all plastic surgery, the cosmetic appearance of the scar depends on accurate approximation of the skin edges.

VARIATIONS IN TECHNIQUE

If the growth extends widely on the inner surface of the lip and on to the alveolar ridge, a segment of the upper border of the alveolar ridge and mandible may be removed by a motor saw. In such cases, the mucosa of the floor of the mouth is readily drawn forward and sutured to the mucosa of the lateral flaps so as to cover the exposed bone. In one case, a wide segment of involved bone was so removed leaving a portion of the lower border of the mandible only about 1.5 centimeters wide to maintain the mandibular arch. The patient has been free of disease for over a year. In such cases, the tissues of the chin are not so well supported and a less satisfactory cosmetic result is obtained.

If the growth involves the entire lower lip or extends beyond the commissures, the vertical incisions must be more laterally placed and should be inclined slightly mesially. So much tissue is

thus excised that closure by lateral flaps alone may be difficult or impossible. In such cases the two triangles are placed more mesially and are brought down as two Estlander flaps attached by very narrow pedicles of the vermilion border only (Fig. 9). Swung down through an arc of 180 degrees, they may be joined in the midline below and help fill the lower lip defect. In this case the mouth becomes quite narrow and a later plastic must be done to widen it (Fig. 10C). If the growth is entirely one-sided and involves the commissure, the procedure may be modified by using an Estlander flap from the same side, either with or without the excision of a Bernard's triangle on the other (Fig. 11).

POSTOPERATIVE CARE

Feeding by nasal tube, although not essential, helps in avoiding gross contamination of the oral cavity for the first 48 hours. Warm boric compresses for the first 48 hours aid in permitting exudation of serum from the lines of incision. Copious irrigations of the mouth with hot saline aids in oral hygiene. The patient may be given bathroom privileges on the second day, at which time the more superficial sutures are removed. All sutures should be removed on the fourth day, otherwise suture marks will remain permanently. The intra-oral sutures may remain until about the sixth or seventh day, when the firm agglutination of the wound edges permits more forced opening of the mouth and better exposure for their removal.

RESULTS

We have performed the modified Bernard operation as described for centrally placed advanced carcinoma of the lip in 7 cases. There has been no operative mortality and primary union has been obtained in all. Of these 7 cases, 4 are living and free from disease for 1, 2, 4, and 6 years, respectively. One patient developed local recurrence because of too narrow excision of the local growth, and died of disease 1 year after operation. One patient died after 2½ years from neck metastases which were not successfully controlled. None of these patients had palpable nodes on admission and no neck dissections were done at the time of the plastic excision of the primary. All received prophylactic irradiation to the neck of about 1½ skin erythema doses by the radium element pack or by X-radiation. One patient died after 3 years, of other causes, without any sign of recurrence up to the time of his death.

The patients operated upon by some variation in technique (Figs. 11 and 12) as described in the latter part of this report comprise a large group of varied character and extent. In a considerable number of the latter, the plastic operations were performed for the closure of healed defects left after eradication of the disease by other methods of treatment (irradiation or cautery). Since surgery was not used as the primary treatment in the entire group, statistical figures are of little value. There has, however, been no operative mortality and primary union has been obtained in all.

SUMMARY

The indications for surgical excision of carcinoma of the lower lip and the general principles of extensive inferior cheiloplasty are discussed. The technique of a modified Bernard operation is described as well as several useful variations.

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FROM THE LAHEY CLINIC

RESECTION OF THE RIGHT COLON AND ANASTOMOSIS OF THE ILEUM TO THE TRANSVERSE COLON AFTER THE PLAN OF MIKULICZ

FRANK H. LAHEY, M.D., F.A.C.S., BOSTON

INTESTINAL suture, particularly when it involves suture of the colon, is a procedure of quite uncertain outcome even in the hands of men with considerable surgical experience and well developed technical skill. This is particularly true in intestinal suture dealing of the proximal colon, for this portion of the colon is filled with liquid fæces and in it exist organisms of high virulence—factors predisposing to contamination and infection.

Anatomically the colon with its irregularity of outline due to its sacculations and its longitudinal bands, with its fat tabs of epiploic appendages, does not lend itself well to intestinal suture by end-to-end, end-to-side, or even side-to-side anastomosis. End-to-end anastomosis of ileum to transverse colon is made difficult and at times impossible with any degree of safety by the disproportion of the caliber of the two tubes of bowel. Lateral or end-to-side anastomoses possess not only the danger of leakage and soiling at the anastomotic suture line but also the danger that the blind ends of the colon may slough out and leak as the result of pressure upon them during postoperative distention. With the idea of overcoming these dangers, we have employed the method here described whereby the entire right colon, and, if necessary, part of the transverse colon may be freed, its mesentery ligated, and the colon removed between clamps aseptically by cutting between the clamps with a cautery and sterilizing the cut ends of the bowel. The two cut ends of bowel may then be implanted into the wound after approximation of the two laterally contacted loops consisting of ileum and colon, to form the double barrelled loop, after the plan of Mikulicz.

A description of the operative plan together with illustrations demonstrating the method is submitted, not with the idea that the method may entirely supplant present methods of preliminary lateral anastomosis and later resection or even primary resection and anastomosis, but because the method is a very safe way of removing the right colon and, if desired, also the hepatic flexure. The method is safe because it eliminates almost entirely the danger of leakage and peritonitis, and because by the scheme which I have suggested (which may be original although that is not important), that is, the staggering of the two intestinal tubes so that the ileal tube is longer than the colonic tube, it is possible to bring about immediate ileal drainage and relief from intestinal obstruction without contamination of the wound.

THE OPERATIVE PLAN

A right rectus incision is made through the abdominal wall and the ascending colon is palpated to discover the location of the growth, its removability, and whether or not liver metastases are present.

If the condition proves to be favorable for resection, the right rectus incision is lengthened upward and downward sufficiently to obtain good exposure of the entire ascending colon and hepatic flexure. The parietal peritoneum external to the ascending colon is cut, as has been suggested by W. J. Mayo, and the entire colon is mobilized and turned inward so that it hangs by its mesentery

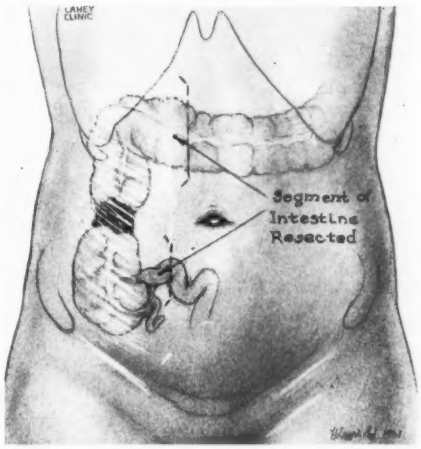

Fig. 1. This diagram shows, in the ascending colon in the shaded area, the location of a supposed malignancy of the right colon. The segment of ileum, ascending colon, hepatic flexure, and transverse colon which is removed by the plan of procedure here suggested, are shown; all bowel, as indicated by the arrow, external to the dotted line, being excised.

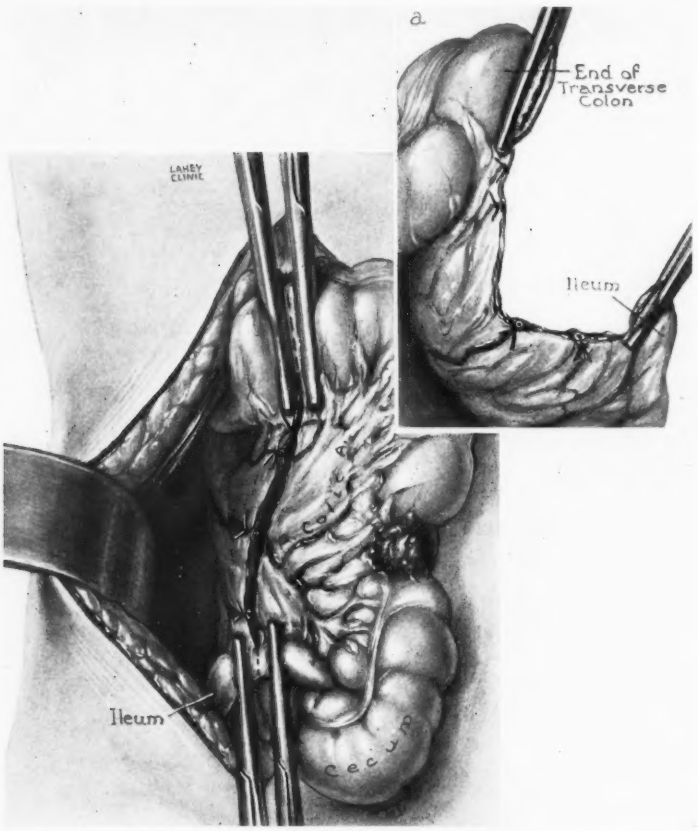

Fig. 2. The external parietal peritoneum to the right of the colon has been incised, the ascending colon and hepatic flexure mobilized and turned inward. The mesentery of the colon, as shown in the main illustration, has been ligated and two Ochsner clamps are applied to the ileum and the colon which is to be incised and sterilized with a cautery along the dotted lines between the clamps. In the main illustration the malignancy is shown in the ascending colon. In insert a, the colon and ileum are shown held in the Ochsner clamps and with their ends sterilized. The segment of involved bowel has been removed.

in which are its nourishing vessels. These vessels of the ascending colon in its mesentery are ligated as close to the root of the mesentery as one desires and the ligation of the mesentery is carried up to whatever point in the transverse colon permits of a margin of safety between the growth of the ascending colon or hepatic flexure. At this point the two Ochsner clamps (Fig. 2) are applied.

In the same manner, ligation of the mesentery of the ileum is carried out up to a point a sufficient distance away from the ileocæcal valve so that two Ochsner clamps can be applied side by side as with the colon (Fig. 2). With a cautery the ileum is severed between the clamps, the entire segment of right colon and its short segment of attached ileum being freed. The proximal ends of cut colon in the upper clamp and ileum in the lower one are thoroughly sterilized with the cautery and the tube of ileum and colon are brought up into the wound and placed in a double barrelled fashion side by side (Fig. 3), after the plan of Mikulicz.

If no obstruction is present, the two ends of colon and ileum are placed side by side at the same level on the abdominal wall and approximated by two rows of interrupted stitches of cat-

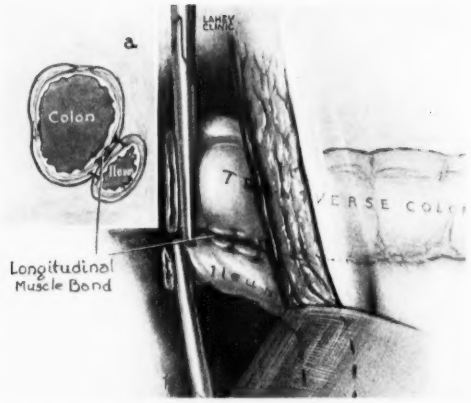

Fig. 3. This diagram shows the ileum placed beside the transverse colon and approximated to it by tacking sutures so that a long double barrelled spur is formed between the two loops of intestine. In insert *a* is shown diagrammatically the method of approximating the ileum to the longitudinal band of transverse colon by anterior and posterior tacking stitch.

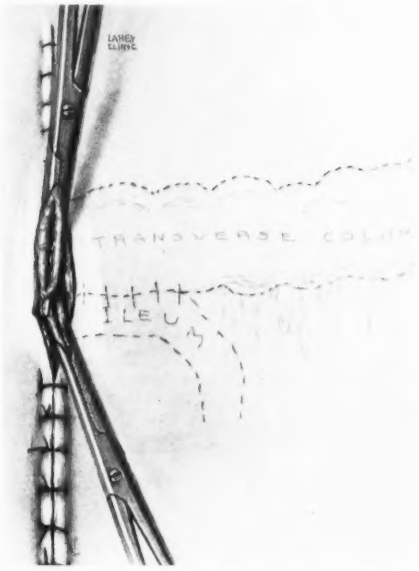

Fig. 4. Diagrammatically one may see outlined through the sutured abdominal wall the ileum approximated, as shown in Figure 3, to the transverse colon. The ends of the colon and ileum are implanted, in the wound, still closed by the Ochsner clamps and having been sterilized by the cautery. The abdominal wound is sutured in layers snugly about the implanted ends of ileum and transverse colon. These clamps will keep the wound clean and uncontaminated until they slough off which is on about the fourth to sixth day, by which time there will be sufficient sealing in of the wound so that contamination will not take place.

gut, care being taken to place the ileum along the band of longitudinal fibers of the colon (Fig. 3), and the abdominal wound is closed in layers about the clamped ends of bowel (Fig. 4). Approximation of the ileum to the colon should be of sufficient length that a fairly long, double barrelled spur will result. This will provide a deep partition, the cutting through of which later with the severing clamp (Fig. 6) will provide a wide opening through which the fæcal stream will be reestablished.

If, due to obstruction, there be any likelihood that immediate drainage from the ileal loop will be necessary, a loop of ileum considerably longer than that of the colon is brought out for a distance of 3 to 4 inches above the level of the abdominal skin and so also 3 to 4 inches above the level on the abdominal wall at which the cut end of colon is placed. The two loops of bowel colon and ileum are now approximated just as described and implanted in the wound by closing the peritoneum, fascia, and skin about the clamped ends of colon and ileum. The loops now appear as in Figure 5. No stitches are inserted between the parietal peritoneum and the bowel wall because of the danger of the stitch in the bowel wall penetrating too deeply, producing leakage, contamination, and peritonitis. Sealing off of the peritoneal cavity about the loops of the enterostomy takes place in a few days very satisfactorily without stitches.

When possible, the laterally approximated ileum and colon should be implanted in the lower angle of the abdominal wound since this portion of the abdominal wall and its anterior parietal peritoneum is lax and movable and permits of easy freeing and closure of the temporary enterostomy at the second operation. This is not absolutely essential, however, as we have implanted the cut end of the ileum and colon satisfactorily in the upper end of the wound.

If both cut ends of bowel, colon, and ileum have been placed at the same level, conditions will be as represented in Figure 4.

If the ileum and colon have been staggered as suggested and described in the text so that a longer segment of ileum projects above the skin level than does that of the colon, then conditions will be as represented in Figure 5.

Should it seem desirable now with the ileum staggered and the wound completely sutured to

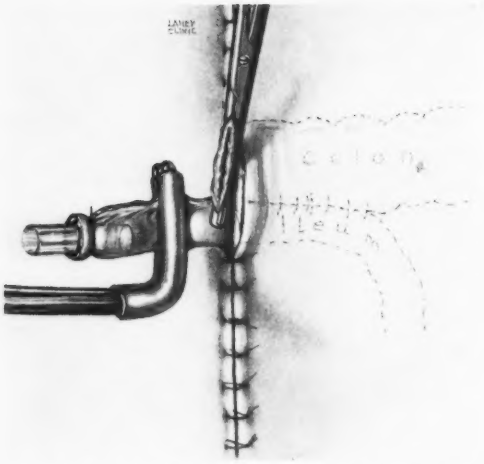

Fig. 5. This is the principle of staggering the ileum and transverse colon, whereby immediate tube drainage may be established in the ileum without soiling of the wound. As stated and shown in the illustration, a longer loop of ileum than transverse colon is pulled out in the wound, Ochsner clamps still being on both segments of bowel. The Ochsner clamp is not shown on the ileum. After closure of the abdominal wound about the two staggered ends of bowel and with the wound protected with gauze, a rubber covered clamp is applied to the long loop of ileum, the Ochsner clamp on the end of ileum removed, a glass Paul or Mixter tube is tied into the end of the ileum and connected by rubber tubing to a bottle at the side of the bed. The rubber covered clamp is then removed and immediate drainage is instituted. Later the redundant ileum is removed with a cautery so that it is on the same level with the end of colon.

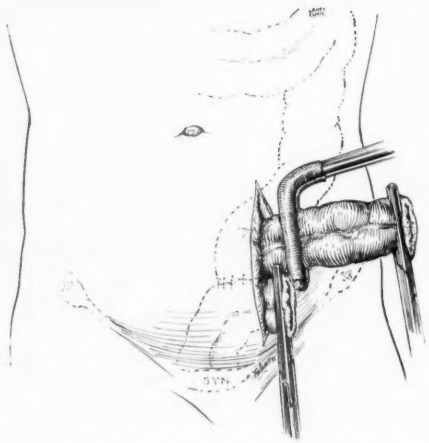

Fig. 5A. This illustration is inserted to show that the same method of staggering and immediate aseptic introduction of a glass tube in the proximal colon may be employed in the Mikulicz plan of resection of the colon as well as in resection of the right colon and anastomosis by the Mikulicz plan of the ileum and transverse colon.

empty the ileum immediately, sterile pads are placed over the wound and about the long ileal loop, a rubber covered intestinal clamp is placed upon the loop of ileum close to the abdominal wall, thus preventing the escape of gas and fæces. The Ochsner clamp is removed from the cut ends of ileum and a glass tube attached to a large rubber tubing is tied into the cut end of the ileum. The rubber covered clamp is now released from the ileum and its contents are allowed to drain into a bedside receptacle. This possibly original suggestion which we have applied not only to the ileum but to the colon in Mikulicz procedures in the colon also has proven to be of real value. (Fig. 5A)

At the end of 4 to 6 days, the clamps obstructing the cut ends of bowel, colon, and ileum (if ileum has not been opened), will slough off from the ends of the bowel and the bowel contents will then drain into the dressing. We have had no real difficulty from wound infection as by this time the wound is sufficiently healed to resist contamination quite well.

If a long staggered loop of ileum has been left, it is at the end of a week cut away with the cautery and its vessels are controlled, until it is on a level with the abdominal wall as is the implanted end of the colon in Figure 4.

At the end of a week or 10 days, an Ochsner clamp is placed in the double barrelled spur of bowel, one jaw of the clamp being placed in the colonic limb and the other in the ileal limb. The two jaws of the clamp are pushed down so that the clamp grasps the greatest possible amount of the spur partition approximated at the first operation, and the jaws of the clamp are closed (Fig. 6). In 4 to 7 days, this clamp comes loose and the new canal along which the fæcal stream is to flow is established (Fig. 6, *a*). It is well at this point to send the patient home for 4 to 5 weeks. Part of the fæces during this time will pass through the cut partition and so along the intestinal canal to the rectum. A considerable part, however, will still be discharged through the common intestinal opening of the ileum and colon in the abdominal wall.

It is this interval which is disagreeable to the patient. Frequently the contents of the ileum are irritating to the skin and the patient is, of course, annoyed by the discharge of liquid fæces on his abdominal wall, since it is difficult, if not

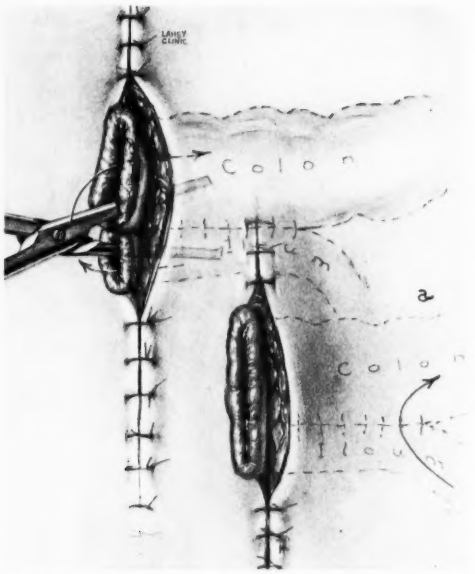

Fig. 6. This diagram illustrates the end of the colon and ileum healed into the wound, the Ochsner clamps have sloughed off, and the double barrelled spur is well established. In the main illustration, on the tenth to twelfth day, an Ochsner clamp has been inserted in the spur so that one jaw is in the colon and one in the ileum after the Mikulicz plan. The clamp is closed and cuts through the partition in from 5 to 6 days thus establishing the fæcal stream along the colon as shown in insert *a* by the arrow, and a common external opening between the ileum and colon, as shown in insert *a*.

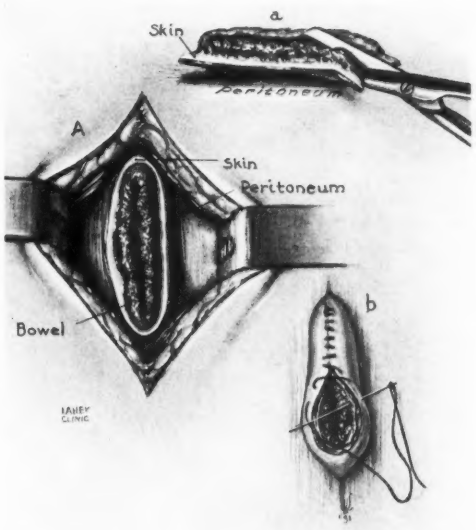

Fig. 7. The main illustration *A* shows a thin strip of skin still adherent to the mucous edge of the enterostomy. Skin, subcutaneous fascia, and muscle dissected away from the common enterostomy made by the ileum and transverse colon with their partition severed. Note that the peritoneum is unopened, still attached at the neck of the tube of bowel. Insert *a* shows adherent skin and mucosa being trimmed away to refresh edges preparatory to inverting and closing the opening of bowel. Note again the peritoneum is still unopened. In insert *b*, the edges of the enterostomy have been refreshed. Any bleeding vessels have been ligated and the bowel is now being inverted by a continuous Connell suture with the peritoneum unopened and the peritoneal cavity is thus in no danger of contamination. Following introduction of the first row of inversion stitches a second reinforcing row further inverting the segment of bowel, but with the peritoneal cavity still unopened, is inserted.

impossible, to catch ileal contents in any kind of a bag or container.

It is desirable not to attempt closure of this common colonic and ileal enterostomy opening earlier than 4 to 5 weeks and better still, 5 to 6 weeks, since it takes this time for œdema to leave the deep portions of the wound and at the end of this time parietal peritoneum has become firmly attached to the limb of colon and ileum, and there is no danger of detaching it in the manipulations of the second closure of the Mikulicz spur and the re-establishment of the fæcal stream.

At the end of 4 to 6 weeks, the patient is taken to the operating room for extraperitoneal closure of the common ileal and colonic enterostomy which has been produced by the cutting of the partition of the Mikulicz spur.

At this stage, we have been considerably disturbed by the irritated condition of the skin about the enterostomy spur. A few days may be spent in attempting to improve it with ointments and powders but if it does not improve, the secondary closure is immediately undertaken regardless of the condition of the skin. The procedure is to be entirely extraperitoneal. Infection of the wound to some degree is to be anticipated and expected and drains are to be placed in either angle of the wound with this particularly in view. For these reasons, no matter how angry the skin may look about the wound, the secondary closure may be proceeded with. As soon as the enterostomy opening is turned in, the skin is no longer irritated by the discharge of ileal contents and clears up at once. Furthermore, the irritation of the skin is largely of chemical origin and not due to infection.

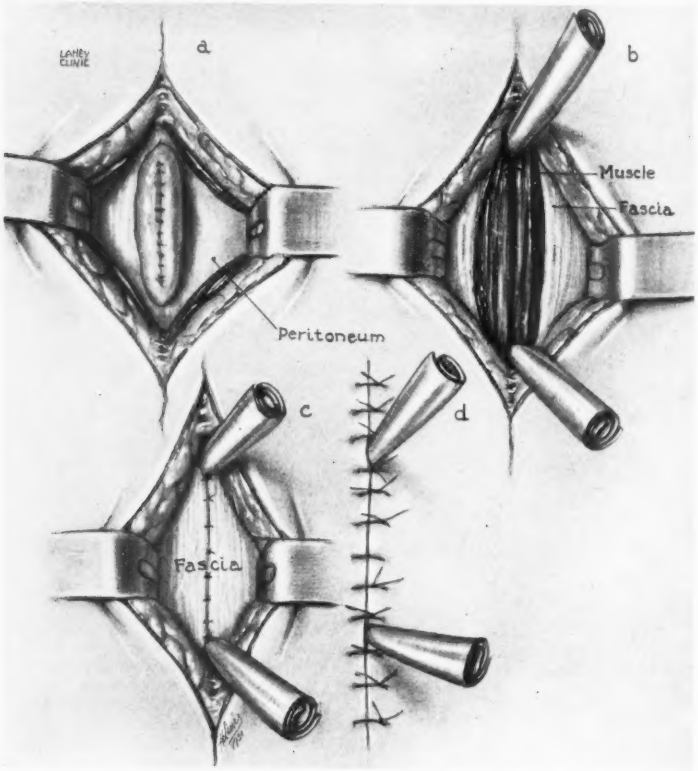

Fig. 8. *a*, The enterostomy opening completely closed and inverted by two rows of sutures, the peritoneum still intact and unopened. *b*, Rubber dam drain inserted down to the sutured enterostomy. The muscle closed over the enterostomy and rubber dam drain. *c*, Fascia closed over muscle. *d*, The skin closed and the rubber dam drain emerging from the upper and lower portions of the wound. Note that even though contamination occurs, the worst that can happen is local wound infection against which danger, drainage has been instituted.

At the secondary closure of the enterostomy, it is first made certain that the Mikulicz spur partition between the colon and ileum has been cut deeply enough so that there is plenty of room for ileal contents to pass into the colon. An incision is then made in the skin around the enterostomy opening about one-fourth to one-half an inch from the point where bowel mucosa joins with the skin. This incision is carried down to the fascia of the rectus and this is separated from the projecting tube of common ileum and colon. Rectus muscle is now likewise separated from the tube of bowel (Fig. 7, *A*).

At this stage then we have the tube of common ileum and colon projecting up into the wound but with the parietal peritoneum of the abdominal wall firmly adherent to its neck and shutting off entirely the peritoneal cavity (Fig. 7, *A*).

The original enterostomy opening with its narrow strip of attached skin which was cut away in the original incision of this secondary operation, is now trimmed away (Fig. 7, *a*), together with any redundant length of the common intestinal tube made up of colon and ileum. Any bleeding vessels in the freshly cut edges of the enterostomy opening are clamped and ligated and an in, out, and over Connell suture closes the opening which was the temporary artificial anus (Fig. 7, *b*). This row of closing suture is reinforced by another row of sutures burying the first row (Fig. 8, *a*). Two pieces of rubber dam are placed over the sutured bowel, one being brought

out at the upper end of the wound and one out at the lower end of the wound. The fibers of the divided rectus muscle are approximated by suture over the drain and sutured bowel (Fig. 8, *b*). The rectus fascia is closed over the muscle (Fig. 8, *c*) and the skin likewise closed with the rubber dam drains emerging from the upper and lower angles of the wound (Fig. 8, *d*).

A moderate degree of infection takes place in most of the wounds but since the repair is all extraperitoneal this occasions no worry and is cared for satisfactorily by the drains at the upper and lower wound angles.

There may and occasionally will be a slight discharge of fæces from the wound, but if the spur has been deeply cut so that there is plenty of room for ileal contents to pass into the colon, spontaneous closure of the fistula takes place.

ADVANTAGES AND DISADVANTAGES

The drawbacks to this operation are the length of time in the hospital involved, about 3 weeks for the first operation and about the same or a little less for the second; the fact that it is a two stage procedure requiring two operations, although the second being extraperitoneal, is not particularly troublesome; the presence of an artificial anus for 4 to 6 weeks; and the irritation of the skin which frequently results from contact with ileal contents.

The advantages are that liquid ileal contents pass readily over through the cut spur opening into the colon. Immediate drainage of the ileum for moderate intestinal obstruction, if desired, by the plan here suggested of staggering the ileum, may be obtained without contamination of the wound. The entire growth and its adjacent mesentery can be aseptically resected and removed at the first operation and without limitation as relates to blood supply of mesentery and the danger of peritonitis from leakage. The bugbear of all anastomoses in large intestine, leakage and peritonitis, is practically eliminated. This operation removing as it does the entire growth with adjacent bowel at the first operation is not subject to the dangers of implantation of the cancer in the wound as is the case in the original Mikulicz operation in which the bowel with contained cancer is not cut away between clamps as here described, but is approximated into two limbs and left in the wound to be cut away at a later operation.

As I have viewed the experiences of patients with this operative procedure in the rather limited number of cases in which it has been applied, ten in number, I am convinced that were it necessary for me to submit to right colectomy, I would unhesitatingly accept the inconveniences and delays associated with this operation rather that the more time saving, less troublesome but more risky features of primary resection and anastomosis. I most certainly would prefer it to preliminary lateral anastomosis and later resection with the necessity of harboring an unremoved and disseminating cancer between the first and second operating stages. It is a much less difficult operation to do from a technical viewpoint and one, therefore, which is safer than primary anastomosis both in the hands of men of great or of moderate experience.

INTERSTITIAL PREGNANCY[1]

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Curator, Army Medical Museum

INTERSTITIAL pregnancy is of more than academic interest even to the general practitioner. It is one of the out-of-the-ordinary conditions of which it is tritely stated, "it occurs more commonly than is supposed." A case report furnishes the opportunity to review the story of the condition for the benefit of those who do not have the time or the facilities to read the special literature. No attempt will be made to analyze critically this literature. Those who are interested will find it covered from 1669 to 1903 by Weinbrenner, and to 1930 by Veit and Weber, Lequeux, Wynne, Blagodarow, and especially Hoehne.

Interstitial pregnancy is one that occurs in that portion of the oviduct that passes through the uterine muscle. There is considerable discussion in the literature over a subdivision into intramural and intracanalicular forms, the former term applying when the ovum develops in the uterine muscle outside of the tube, and the latter when the ovum develops solely within the tube lumen. There is no practical significance to this differentiation, however, and, as a matter of fact, it is unlikely that either occurs in pure form. The very nature of the conditions precludes the likelihood of the tube remaining intact for very long after implantation of the ovum. Though the tube plays a part in the formation of the sac, it must soon lose its identity by compression and erosion. True intramural pregnancy, one that develops in the muscle, leaving the tube intact and patent, must be rare. Raschkes says that no such case had been described up to 1903.

However, the following classification based on the site of implantation of the ovum has practical significance, for the outcome of the case depends somewhat on the localization:

1. Utero-interstitial, when the ovum imbeds in the third of the tube adjacent to the uterine cavity.
2. Tubo-interstitial, when the ovum imbeds in the outer third.
3. True interstitial, when the ovum imbeds in the middle third.

This classification is similar to that of Veit and Weber, of Scott, of Weinbrenner, and of Hoehne.

INCIDENCE

Interstitial pregnancy is rare, but it does occur more frequently than either ovarian or primary abdominal pregnancy, and it is very likely that the incidence is keeping pace with the increase in the general group of ectopic pregnancies. There is probably a maximum of 200 reported cases that will withstand critical analysis as to the accuracy of diagnosis. It is likely, as Hoehne suggests, that a number of cases that have ruptured have been diagnosed incomplete uterine abortion, and curetted, and the rupture attributed to the curette. Such a situation, by the way, may be of medico-legal importance, as is illustrated by Maschka's case in 1885, and by several others since.

Figure 1 illustrates the relative frequency of the various forms of ectopic pregnancies.

ETIOLOGY

There is a surprising variation in the anatomy of the interstitial portion of the tube. While in some cases the tube runs a straight course, it more commonly has a bow, with the curve toward the upper and posterior levels of the cornu. As a further complication, there may be definite sharp bends. In Blagodarow's first case, there were 5 such kinks in the unaffected tube, and he attributed the arrested passage of the ovum to a similar condition in the affected tube.

The tube is narrowest in its interstitial portion, averaging not more than 0.8 millimeter in diameter. The impregnated ovum, increasing in size during its passage down the first portions of the tube, may be mechanically blocked on reaching this constricted area. The mucosa of this portion of the tube is normally the thinnest and freest from folds, but areas may be thicker than normal and resemble endometrium; there may be definite adenomatous hyperplasia, particularly at the bends; or there may be diverticula and splits in the mucosa. Any of these deviations from the normal may determine the site of implantation.

In addition to these anatomical peculiarities, inflammation may play an important rôle. An endometritis may so compromise the uterine mouth of the tube that, while spermatozoa may enter the tube, the ovum can not escape; or a salpingitis may extend into the interstitial portion of the tube and further reduce its lumen by exudate, by exfoliation of epithelium, particularly during menstruation, or by adhesions. This will be more of an etiological factor if the ovum enters the tube from the uterus, for the same conditions

[1] From the Army Medical Museum and the Columbia Hospital for Women, Washington, D. C.

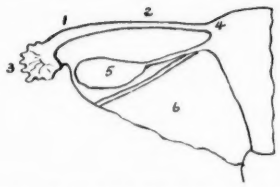

Fig. 1. Diagram to show the relative incidence of the various forms of ectopic pregnancy. *1*, Ampullar; *2*, isthmian; *3*, infundibular; *4*, interstitial; *5*, ovarian; *6*, primary abdominal. (After Kerr and Ferguson.)

exist in the free portion of the tube, and they will probably arrest the ovum that enters from the abdominal cavity before it reaches the interstitial portion.

That impregnation of the ovum can occur in the abdominal cavity is proved by the cases of pregnancy in rudimentary horns, since the latter have no communication with the uterine cavity. An ovum, particularly if from the opposite ovary, impregnated in the abdominal cavity, may grow too large to pass through the interstitial tube by the time it has traversed the abdominal cavity and the free portions of the tube.

Scott attributes his four cases to the curettage that had been performed on each one some time before the interstitial pregnancy had developed. A number of the other cases had previous pelvic operation. Intramural myomata may compress the tube sufficiently to prevent passage of the ovum, or possibly the ovum impregnated in one tube may traverse the uterine cavity and enter the opposite tube, by which time it has grown too large to force its way beyond the interstitial portion.

Interstitial pregnancy occurs most commonly in multipara between the ages of 25 and 35 years. A few more cases have been reported as occurring on the right side than on the left, and Wolf wonders if appendicitis may not be an etiological factor, but there is no evidence to support the conjecture.

An occasional case of bilateral interstitial pregnancy has been reported, one of them by Woolf. Of particular interest are the ones occurring in the stumps remaining after salpingectomies. Richardson reports one such case, and he was able to collect seven others from the literature, including Nacke's case in which interstitial pregnancy occurred 3 months after he had attempted sterilization of his patient by removing both tubes! The stumps had, of course, become patent, but it is a question whether the ovum had entered through the uterine or the abdominal end. Richardson credits the latter route under these conditions.

Fig. 2. Interstitial pregnancy. *1*, Adherent omentum; *2*, right ovary; *3*, gestation sac containing collapsed amnion and placenta; *4*, rupture, exposing placenta; *5*, edge of communication between sac and uterine cavity; *6*, arrow points toward left cornu; *7*, uterine cavity; *8*, left ovary showing cross section of corpus luteum. There is some exaggeration of the difference in levels of attachments of the adnexa on the two sides. (Army Medical Museum Accession No. 30396. Negative No. 47591.)

PATHOLOGY

As has been intimated, the gross and microscopical pathology of interstitial pregnancy is largely dependent on the anatomy of the part. Because of the simplicity and thinness of the mucosa, there is little or no decidual reaction, so that on penetration, the ovum is practically always in direct contact with the uterine muscle. This latter the chorionic villi destroy, infiltrate, and compress in the line of least resistance which, on account of the location of the tube, is toward the superior and posterior of the involved cornu. With the growth of the ovum, the wall becomes gradually thinner, until after a few weeks it consists only of serosa, a few strands of connective tissue, and uterine muscle. This method and direction of enlargement is practically constant and is not dependent on the implantation of the ovum in the middle third of the tube. Naturally, when the ovum has implanted near the

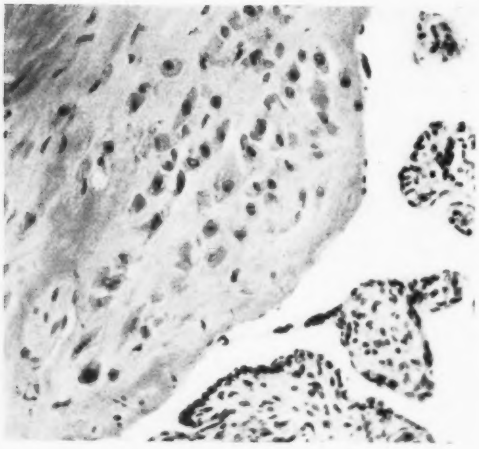

Fig. 3. Section through sac wall to show chorionic villi, decidual reaction, and hypertrophied muscle fibers. (Army Medical Museum Accession No. 30396. Negative No. 49346. ×85.)

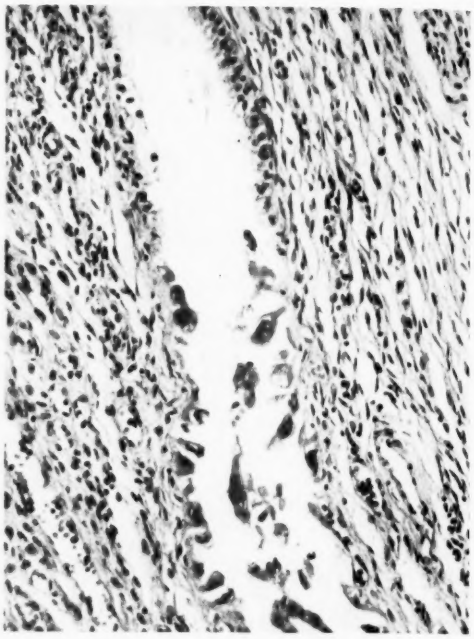

Fig. 4. Section of cervix to show transition of glandular epithelium to decidua-like cells and the hypertrophy of the muscle. (Army Medical Museum Accession No. 30396. Negative No. 49385. ×150.)

uterine orifice and is expelled or escapes by rupture of the intervening septum into the uterine cavity, the typical deformity of the uterus does not occur, but then, it is no longer an interstitial pregnancy.

Two classical signs that are dependent on this location and direction of the enlargement are recognized to be of great importance in the anatomical diagnosis. These are:

1. The Ruge-Simon syndrome, which consists in the elevation of the affected cornu; the displacement of the fundus toward the opposite side; the rotation of the uterus on its long axis (due to pull of the round ligament); and the insertion of an intact tube into the inferior surface of the enlargement.

2. The Baart de la Faille sign, which is simply that the sac is attached to the fundus by a broad base. This is constant. A gestation sac attached to the uterus by a pedicle cannot be an interstitial pregnancy. But the Ruge-Simon sign may not be apparent in very early pregnancies or when the uterus is fixed in position by adhesions. Its absence, therefore, does not exclude the possibility of an interstitial pregnancy.

In addition to these two signs, the following points are significant: the round ligament is lateral to the sac; the round and ovarian ligaments and tube on the affected side are more widely separated at their insertions into the cornu than are those on the opposite side, and they are all at a higher level. The sac is separated from the uterine cavity by a wall, but it may communicate with the uterine cavity through the distended uterine orifice of the tube, or through a break in the wall; uterine muscle completely surrounds the sac; and the isthmus of the tube is intact.

The uterus usually shows some general hypertrophy; the cervix may be soft and the canal be plugged with mucus as in normal pregnancy. Decidua may be present in the uterine cavity, but it is not likely to be if the pregnancy is advanced, or if the ovum has died. In the latter instance it is exfoliated and discharged, as it is in ordinary tubal pregnancy. Decidua may or may not be present in the wall of the sac, and when present it is never massive. The Langhans' cells from the villi may be mistaken for decidual cells. The sparce decidua exposes the muscle to attack by the villi, which develop all over the outer surface of the sac and can be seen lying on the uterine muscle and infiltrating it. There is usually a certain amount of connective tissue reaction in the involved musculature. The muscle fibers may show the hypertrophy of pregnancy,

while those adjacent to the villi will show regressive changes. The thin portion of the sac may be devoid of muscle, the villi seemingly impinging directly on the peritoneum. The omentum and intestines are not infrequently adherent to the sac.

Pregnancy in a rudimentary horn can closely simulate an interstitial pregnancy, but in the former there is not the disturbance in position of the fundus (Ruge-Simon's sign); there are more apt to be vestiges of uterine mucosa and a decidual reaction about the sac; and there is less likelihood of a communicating opening between the sac and the uterine cavity. When there is such an opening it will be recessed, and the dividing wall will not bulge into the uterine cavity.

Pregnancy in one horn of a bicornate uterus can be differentiated by three points: The tube is attached to the lateral surface of the sac; there is a decidual reaction comparable to that of the uterine mucosa and the decidua extends into the tube; and the tube lumen, particularly in the early stages, communicates with the sac.

In tubal pregnancy, the involved tube is distorted, shorter than its fellow, and the sac may have a pedicle formed by the uninvolved portion of the isthmus. The round ligament is attached between the sac and uterus, except in pregnancy of the isthmus immediately adjacent to the cornu. In this last instance, the cornu may be passively enlarged by invasion of villi, and the round ligament will come off from the anterior surface of the sac. There will, however, be no disturbance in position of fundus, and the distal portion of the tube will be attached to the lateral aspect of the sac instead of to the inferior.

DIAGNOSIS

There is very little on which to base a clinical diagnosis of interstitial pregnancy. The review of a number of cases suggests a few vague points of differentiation, but these lose much of their significance when applied to the individual case. The diagnosis has been made but rarely before operation, or even suspected. The most suggestive point, in the presence of symptoms indicating pregnancy, is the palpation of a mass attached by a broad base to one cornu of the uterus; but in several cases in which such a mass was palpated, the diagnosis was made of a soft myoma in the cornu of a normally pregnant uterus. If one is fortunate enough to detect by a series of palpations the gradual enlargement of such a mass, a diagnosis can be made with greater assurance. Blagodarow reports such an experience in one of his cases. Of course, palpation after rupture of the sac is difficult, and particularly so if the sort of base any recognizable mass might have is to be determined. It is suggestive to find the body of the uterus larger than it would be in a tubal pregnancy of the same age.

The symptoms both before and after rupture may be identical with those in a tubal pregnancy, and it is practically impossible to differentiate, particularly before rupture, from a pregnancy in a bicornate uterus or from one in a rudimentary horn. It is true that such general symptoms as abdominal pain, nausea, and prostration may recur over a longer period of time than they do in a tubal pregnancy, but at the time of rupture there is the same story of sudden, intense, lower abdominal pains, collapse, and evidence of internal hæmorrhage. The majority of cases give a history of irregular vaginal bleeding, but there is more likely to be amenorrhœa than in tubal pregnancy. On the other hand, there may be no interruption of the normal menses.

The discharge of fetal elements is, of course, important evidence for differentiating the abortion of a normal uterine pregnancy; and the pulse, temperature, and blood picture are useful in excluding an abdominal inflammation. There is finally the possibility of confusing a normal pregnancy in a laterally flexed uterus with interstitial pregnancy.

In spite of these difficulties in diagnosis, more cases will be recognized before rupture if clinicians will follow Braddock's and Scott's reasonable suggestion to keep in mind the possibility of an interstitial pregnancy when examining any woman in the child bearing age with any deviation from the normal menstrual cycle.

COURSE

As might be supposed, in the majority of cases the diagnosis is not made until after the rupture, and because of the severity of the hæmorrhage, the mortality is approximately three times that of tubal pregnancy, if we accept Schumann's rate of 4 per cent for the latter. He cites, by the way, the decrease in mortality from ectopic pregnancy from 80 per cent in 1875. This is due to the improvement in surgical procedure, and to the lessened tendency to delay operation. There is no question but that interstitial pregnancy is the most dangerous form of the ectopic implantations, and this is due in part to the misleading lack of severity in the early symptoms in some cases.

Rupture in interstitial pregnancy occurs on an average 4 weeks later than it does in tubal pregnancy. Waegeli critically analyzed all the cases

he could find in the literature up to 1914, and found that of 38 cases

4 ruptured in the first month
11 ruptured in the second month
9 ruptured in the third month
7 ruptured in the fourth month
3 ruptured in the fifth month
1 ruptured in the sixth month
3 ruptured in the seventh month.

Werth found that of 32 cases, 19 ruptured before the end of the third month, and that rupture occurred most commonly during the third month.

The rupture occurs in a large majority of cases on the superior and posterior surface of the sac. It is possible that hæmorrhage is greater in those cases that rupture early than it is in the older pregnancies, for in the latter, the vascularity of the portion of the sac that ruptures has been greatly reduced by the atrophy and destruction of the uterine wall. Fatal hæmorrhage does not necessarily follow rupture, and the embryo may escape into the abdominal cavity and continue to grow.

The mortality rate is directly dependent on whether the case is operated on before or after rupture. Practically every case reported that was operated on before rupture survived.

Aside from rupture into the abdominal cavity, which is the commonest termination of the process so far as can be determined, the sac, if implantation has occurred near the uterine orifice of the tube, may rupture into the uterine cavity, whence the contents are usually discharged. But the embryo may, theoretically at least, establish itself there and mature. This last outcome would be possible only with the development of a satisfactory placenta. It would be impossible to say from clinical evidence how many uterine abortions had their origin in an interstitial pregnancy, and it would be equally difficult, even by postmortem examination, to determine that a pregnancy maturing in the uterine cavity had started as an interstitial pregnancy. We can only assume that either may occur and that they may, after all, be the most frequent and certainly the happiest outcomes of a potentially serious condition.

One of Wagner's cases is of interest in this connection. His patient aborted after an amenorrhœa of 8 months. The product was a 3 to 4 months old embryo with a marked constriction between the sac and the placenta. He considered it a tubo-uterine pregnancy, and he interpreted the constriction as having been caused by pressure of the rim of the uterine opening of the tube.

Warzawski's case will also bare citing. The tubo-uterine opening was large enough to have resulted in a tubo-uterine or uterine pregnancy, if the placenta had not occluded the opening. Raschka called the condition "placenta prævia tubo-uterina."

Implantations near the isthmus may rupture into that part of the tube and behave as an ordinary tubal pregnancy; or may, very rarely, rupture between the layers of the broad ligament.

After the ovum dies, the syncytium may continue to grow and invade the maternal tissues, or a blood mole may develop in the sac. The more mature embryo or fetus may become a lithopedion.

TREATMENT

Laparotomy is indicated in every case. The recommendation to curette *per vaginam* is theoretically interesting but practically too dangerous, and curettage of the sac after the abdomen is opened may result in fatal hæmorrhage. The only conservative measure is excision of the sac and all the involved uterine muscle. It has occasionally been possible to reimplant the tube, but usually the tube must be removed with the affected cornu. If the pregnancy is far advanced, or the uterus myomatous, or if time is a factor, it is necessary to do a hysterectomy. The more conservative measure should be taken, especially in young women, when a functioning and non-infected uterus can be preserved.

There is virtue in Braddock's recommendation to withhold stimulants and transfusion after rupture until the hæmorrhage has been controlled. It is necessary, of course, to combat the effects of hæmorrhage by transfusion and stimulation so soon as practicable.

CASE REPORT

Mrs. V. A. S., aged 36 years, white. Menses began at 14, and had been of the 28 day type of 4 to 5 days' duration, with no attending discomfort. She had had 6 children, all of them living and well, but information as to their ages is not available. In 1921, she was operated on for prolapse of uterus, presumably a suspension. In 1926, she had a dilatation and curettage and radium treatment for menorrhagia, the duration of which is not known.

Last menstrual period began October 5, 1928. In December of the same year she suffered from cramp-like pains in the lower abdomen (there is no record of vaginal bleeding) and was admitted to the hospital for a possible ectopic pregnancy. The diagnosis, however, was a normal pregnancy of 2 months' duration. There is no record of the conditions observed during that admission.

She was free from symptoms until the morning of March 24, 1929, when she was seized with severe, cramp-like pains in the lower abdomen. These became more severe in the afternoon. There is no record of vaginal bleeding. She was admitted to the Columbia Hospital at 8 p.m. in a moribund state. Her abdomen was distended, there was dullness in both flanks, she was comatose, and almost pulseless. She failed to respond to venoclysis and direct stimulation of the heart with adrenalin and died in about

an hour. No vaginal examination was made or any attempt at operation, though it was recognized at this time that she was suffering from a ruptured ectopic pregnancy.

Necropsy: Body was well developed and nourished; breasts were those of a well advanced pregnancy. The thymic mass was rather larger than normal for her age. There were approximately 2 liters of fluid and clotted blood in the abdominal cavity, and her tissues were practically exsanguinated. The omentum was firmly attached to the upper edge of the fundus and to the sac in the right cornu of the uterus. The anterior surface of the uterus was firmly adherent to the abdominal wall along the scar of the former laparotomy wound. The kidneys showed considerable degeneration.

Gross description (Fig. 2): The uterus was generally enlarged, and the right cornu was distorted by a globular, sac-like swelling 11 centimeters in diameter. The omentum was attached to this sac for a distance of 7 centimeters along the superior surface. On the left anterior surface was a rent 4 centimeters long through which chorionic villi protruded. The adnexa of the right side were attached at a level approximately 5 centimeters higher than were those of the left side, and bore the classical relationship to the sac, the round ligament lateral to the sac, the tube attached to the lower border. The left tube was 9 centimeters long, the right was 10.5 centimeters long. Both were of normal diameter, patent to the cornua and free from inflammation. The right tube did not communicate with the sac. The insertions of the left tube and round ligament were 1.5 centimeters apart, those of the right tube and round ligament were separated by 4 centimeters. There was a large corpus luteum in the *left* ovary, obviously the one concerned in this pregnancy.

On palpation through the rather roomy cervix before the uterus was opened, the finger entered a definite constriction. This was thought to be the internal os, but it proved to be an opening in the wall dividing the sac from the uterine cavity. It was 2.5 centimeters in diameter, and through it bulged a sizable portion of the amniotic sac. Its edge was thin, smooth, rounded, and of fibrous consistency, but the dividing wall expanded rather abruptly, became muscular, and merged with the fundus from which it was obviously formed. It was not possible, however, to determine whether the opening was a tear in the wall or the dilated uterine orifice of the right tube. The impression was that it was the latter. The sac contained an intact amnion in which floated a 5 to 6 months' male fetus with the cord wrapped three times about its neck. The fetus was well developed and in good condition, apparently having died shortly before the patient. A well developed placenta lined the sac, except in the upper and right lateral portions. The upper half of the sac was very thin, translucent, and apparently reduced to serosa, except where reinforced by the adherent omentum.

The wall of the remaining fundus was hypertrophied, averaging 2 centimeters in thickness. The cavity was roomy, measuring 4 centimeters from the internal os to the dividing wall of the sac. The left cornu could be identified extending upward to the left behind the dividing wall. The endometrium was thickened and quilted apparently from decidual reaction. The cervix was elongated, softer than normal, and its canal contained a mucous plug similar to that seen in a normal pregnancy. The mucosa of the cervix was also thickened and contained a number of small cysts toward the external os.

Microscopical findings: The wall at the site of rupture showed a few strands of hypertrophied muscle and some connective tissue. Internal to this was a thicker zone composed largely of decidual cells, and resting on this layer and attached to it were numerous chorionic villi (Fig. 3). The syncytial layer was usually missing over the surface of the villi attached to the maternal tissue.

The section taken from the posterior wall of the sac over the placental site, and at a point where the wall was very thin, showed practically no muscle and no decidual reaction. A thick layer of necrotic material in which an occasional villus could be recognized was attached to the inner surface. There apparently had been a subplacental hæmorrhage at this point. No decidual reaction was seen in blocks from the anterior wall of the sac near the insertion of the right tube, and at no point was real invasion of the uterine muscle by villi encountered.

A section from the fundus where it was split by the sac showed villi penetrating superficially a layer of semi-necrotic material, and here they were in contact with maternal blood. Deeper in, were larger blood spaces, but no villi.

The inner surface of the fundus showed some scattered foci of decidua-like cells, but generally the mucosa was missing, and there was a thick layer of partially necrotic tissue containing groups of nuclear fragments, but no glands were seen. A uterine decidua had evidently formed and had been discharged. Beneath this layer were large blood spaces, and the musculature of the entire fundus and cervix was hypertrophied. The mucous glands of the cervix were active, and the epithelium in places showed a transition into decidua-like cells.

This case presents the classical gross features of an interstitial pregnancy which persisted beyond the common age of rupture. It is probable that the adhesions protected the sac from an earlier rupture, and they prevented a very marked degree of lateral displacement of the fundus. The character of the opening into the uterine cavity and the patches of decidual reaction in the wall of the sac indicate that implantation was intracanalicular and not intramural and that the sac was primarily in the tube lumen, although the tube lost its identity and its mucosa was largely destroyed during the growth of the fetus.

It is doubtful if the uterine adhesions were of etiological significance, because they were superficial and the tubes were not involved. The only evident possibility as to cause is the presence of the corpus luteum in the ovary on the side opposite to that of the pregnancy. Assuming that the ovum was impregnated directly on discharge, it could have grown too large to pass through the right interstitial tube while traversing either the uterine, or the abdominal cavity.

This case illustrates very well the misleading lack of severity of symptoms in the early months of an interstitial pregnancy.

I wish to acknowledge my gratitude to Dr. G. Brown Miller of the Columbia Hospital Staff for his permission to report this case.

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THE SYNDROMES OF GASTRO-ILEOSTOMY AND GASTRO-ILEAC ULCER

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ANASTOMOSIS between the stomach and small intestine has become the procedure of choice in the hands of many surgeons for the treatment of lesions of the stomach and duodenum. The operation may be carried out with associated gastric resection or by simple anastomosis. There have been many varieties of such anastomosis, especially as to the type of loop, whether long or short, isoperistaltic or antiperistaltic, and as to the length and site of the stoma. However, in the operation which is ordinarily called gastro-enterostomy it is intended that the jejunum should always be used for the anastomosis and the operation should therefore more accurately be termed gastrojejunostomy.

It is our intention to present a series of cases in which gastro-ileostomy was performed instead of gastrojejunostomy and to point out some of the results following this distinctly abnormal anastomosis by which the jejunum and parts of the ileum are short-circuited. That a loop of ileum instead of jejunum was used in these cases in forming the anastomosis seems to indicate clearly easily avoided surgical error. In 2 of the 7 cases of gastro-ileostomy to be reported, there was definite secondary ulceration of the ileum with the formation of an ulcer. In one case there was thickening of the gastro-ileac stoma suggestive of gastro-ileitis. In a search of the literature we found reports of only 2 cases of gastro-ileostomy. Carroll, in 1915, reported having operated on a negress aged 26 years on whom a gastro-ileostomy had been previously performed; the anastomosis was made in the ileum, 50 to 60 centimeters above the ileocæcal valve. The second case was reported by Mercur, in 1917, and was that of a woman aged 38 years; the anastomosis was about 16 centimeters in length and was placed between the stomach and ileum. In neither of these cases, in both of which exploration was subsequently carried out and the anastomosis disconnected, was there secondary ulceration in the ileum. The primary operation in both cases had been made because of ulceration with hæmorrhage of the stomach.[1]

[1] The only case of gastro-ileac ulcer recorded in the literature of which we are aware is that reported by Klein (Klein, Eugene. The fundamental principles of the treatment of gastric and duodenal ulcers. Arch. Surg., 1926, xiii, 730–743). He mentions that Berg "found a large indurated gastro-ileal ulcer in a patient in whom a surgeon had by mistake performed a gastro-ileostomy."

Our series consists of 7 cases of gastro-ileostomy, in 1 of which jejuno-ileostomy also was performed, and 2 cases of gastrojejunostomy and jejuno-ileostomy. These operations had all been performed prior to the registration of the patients at The Mayo Clinic, and in all except 1 case, operation was subsequently performed at the clinic. We have, therefore, in all except 1 case, surgical confirmation of the presence of gastro-ileostomy or jejuno-ileostomy and in the unexplored case there was little doubt, from clinical and roentgenologic examinations, of the presence of the aberrant anastomosis.

REPORT OF CASES

CASE 1. A woman, aged 35 years, a Russian Hebrew, first came to The Mayo Clinic because of abdominal pain. Cholecystectomy for cholecystitis with stones had been performed 1 year before admission, and 6 months afterward gastro-enterostomy for a "scar in the duodenum close to the pylorus" had been performed. The symptoms preceding gastro-enterostomy had lasted for 3 months and consisted chiefly of severe upper abdominal pain which came on irregularly. Nausea and vomiting followed the eating of all types of food. Other symptoms were epigastric fullness, regurgitation of acid, periodic epigastric pain, and slight lower abdominal pain with diarrhœa consisting of four or five loose stools daily at intervals, and persisting for 2 or 3 days. The patient had lost from 20 to 30 pounds in weight.

Examination disclosed mild secondary anæmia. The fractional gastric analysis showed free hydrochloric acid 30 and total acidity 50; 140 cubic centimeters was recovered. Roentgenograms revealed a small gastrojejunal ulcer opposite the stoma, deformed duodenal cap, and patent pylorus. A diagnosis of gastrojejunal ulcer was made and surgical treatment was advised. The patient went home for 6 weeks before returning for operation and during this time the symptoms persisted with perhaps more pain above and to the right of the umbilicus.

At operation an ulcer was found opposite an anastomosis made in the upper part of the ileum. The gastro-ileostomy loop was disconnected, the ulcer was excised, the opening in the ileum was closed and partial gastrectomy of the posterior Pólya type was done. The pathologist reported a gastro-ileac ulcer 6 millimeters in diameter. Convalescence was uneventful.

Prior to the gastro-ileostomy the symptoms were not those usually assumed to be diagnostic of ulcer, and apparently active ulcer was not present in the duodenum at the time of the operation. Despite this fact an ulcer developed just below the ileac anastomosis. Through some error the ileum was attached to the stomach on the assumption that gastrojejunostomy was being performed.

CASE 2. A Hebrew, aged 44 years, first came to the clinic because of "stomach trouble" of 15 years' duration. The early symptoms were described as "navel cramps." Because of suspected disease of the gall bladder he had been operated on elsewhere 4 years previously. At that time a gastric ulcer was also found. The gall bladder was removed and some type of operation on the stomach was attempted. A second operation, presumably entero-enterostomy, was performed shortly thereafter because the "stomach did not empty." Following the operation the patient remained well for a year, after which periodic epigastric pains developed 3 hours after meals and were relieved somewhat by eating. He also had two rather severe gastro-intestinal hæmorrhages, the last 8 months previous to registration at the clinic. At this time the epigastric pain was sharp and colic-like with radiation through to the back and downward toward both iliac fossæ and it had become so severe that flexion of the thighs was necessary for relief. Vomiting had not occurred but the patient had lost 18 pounds in weight in 4 years, and was constipated.

Examination revealed the presence of secondary anæmia. Peristaltic waves were visible in the abdomen and many gurgling noises were heard. Total acidity of the gastric contents was 46, and free hydrochloric acid was 34; 60 cubic centimeters was recovered. Roentgenograms showed the gastro-enterostomy to be free, the stoma close to the pylorus with the loop turned to the right, and a small deformity of the jejunum just opposite the stoma.

Gastrojejunal ulcer was diagnosed and at operation a gastro-iliac ulcer was found. The former gastro-enterostomy had been done posteriorly on the stomach near the pylorus to a loop of the upper part of the ileum, turned from left to right. A patulous stoma of an entero-enterostomy was found 25 centimeters below this. The gastro-iliac ulcer was excised, the gastro-enterostomy loop was cut off, and the openings in the stomach and ileum were closed. The pathologist reported simple gastro-iliac ulcer 9 millimeters in diameter.

The patient recovered uneventfully and 4 years later reported by letter that he was very well and had been well since the operation.

At the first operation cholecystitis and a gastric ulcer were found for which, evidently, cholecystectomy and gastro-ileostomy had been performed. Entero-enterostomy was done at a subsequent operation which was performed because of obstruction. The patient remained well for several months, when symptoms, again suggesting ulcer, developed. This time the pain came on lower than the original pain and was referred downward into the iliac fossæ. The case presented the usual ulcer characteristics.

CASE 3. A man, aged 39 years, came to the clinic because of abdominal pain and vomiting. For 10 years he had experienced recurring gastric disturbance characterized by indefinite pain in the upper part of the abdomen with radiation into the thorax and back, occurring about 3 hours after meals, with complete ease from food and soda. Twenty months before admission to the clinic the pain had become so severe that morphine was required for relief. A month later he was operated on elsewhere and anterior gastro-enterostomy for gastric ulcer was performed. The pain was relieved but his bowels became loose; he often had as many as twenty stools a day. Undigested food was passed in an hour. The patient lost weight. At the end of a year the number of stools had diminished to three a day, although they were still loose and were passed about 5 minutes after meals. He was conscious of much peristaltic movement of the intestines, especially in the left side. Several weeks after operation vomiting began and he expressed the belief that he was vomiting fæcal matter. The general condition was fairly good although he had lost 45 pounds.

Examination was essentially negative save for deep-seated swelling above the right clavicle which it was thought might be carcinomatous metastasis, but later was diagnosed as lipoma. Total acidity of gastric content was 72 and free hydrochloric acid was 58; 100 cubic centimeters was recovered. Roentgenograms disclosed duodenal deformity and slight irregularity of the stoma with dilatation of the jejunum. The roentgenologist thought that a gastrojejunal ulcer might be present.

The patient was operated on with a clinical diagnosis of gastro-ileostomy and at operation the diagnosis was confirmed. The jejunum was explored for about 2 to 2.5 meters. There was some thickening at the stoma which was possibly due to gastro-ileitis, but ulcer at the stoma could not be demonstrated. There was an old ulcer at the pylorus. The stoma was separated and the openings in the stomach and ileum were closed.

The patient recovered uneventfully and 7 years later reported by letter that he was in perfect health, and had regained all his weight.

In this case the operative procedure was undertaken because of an ulcer at the pylorus. Instead of gastrojejunostomy, gastro-ileostomy was performed, apparently low in the ileum. The symptoms which developed following the operation were characteristic of this type of anastomosis. There was some thickening of the stoma which was similar to that seen occasionally surrounding a gastrojejunostomy stoma performed for peptic ulcer. It is a condition which is perhaps analogous to that of gastrojejunitis (4), in this case a condition suggesting gastro-ileitis.

CASE 4. A woman, aged 35 years, came to the clinic because of intermittent gaseous distention, pyrosis, and nausea within 30 minutes after eating, which had been present for 4 or 5 years. She vomited occasionally, but had no pain. She had lost 40 pounds in weight. She remained practically on a milk diet for 2 years, during which time she was free of symptoms and regained the lost weight. Five months before her admission, gastro-enterostomy was performed for duodenal ulcer. Fifteen days later the surgeon found it necessary to perform entero-anastomosis over a Murphy button on account of vomiting. A fæcal fistula developed in the wound but this gradually healed and she remained well for several weeks. After this time the old but more severe symptoms recurred and were associated with vomiting, fever, and glossitis. She had lost 92 pounds. Diarrhœa had been present for 3 weeks.

The patient was extremely emaciated and debilitated. The blood pressure was low, the temperature was 100 degrees F., and the pulse rate 130. On the tongue were large, thick, translucent placques of membrane which were due to thrush and the perineal area was raw and excoriated. Abdominal examination elicited tenderness beneath the scar on the right side. The hæmoglobin was 75 per cent, leucocytes numbered 9,000, and the differential count was normal. The blood urea was 40 milligrams in each 100 cubic centimeters and the blood chlorides and carbon dioxide combining power of the plasma were within normal

limits. The patient was not strong enough to stand any special gastro-enterologic or roentgenographic examinations. Little improvement occurred under vigorous medical treatment, although the thrush responded well. Vomiting continued and fæcal material was frequently included in the vomited gastric content. Fæcal material was lavaged from the stomach on several occasions. Despite the patient's poor condition, surgical exploration was advised on account of the apparent signs of intestinal obstruction.

On the morning of operation, 1 liter of fæcal matter was lavaged from the stomach. At operation gastro-enterostomy was found with anastomosis of the posterior wall of the stomach to the jejunum, and entero-anastomosis between the jejunum and the lower part of the ileum just above the cæcum. The upper part of the jejunum was friable and diffuse inflammation was present. Disconnection of the gastro-enterostomy loop and entero-anastomosis were carried out. The patient died 36 hours later. Necropsy was not obtained.

CASE 5. A woman, aged 44 years, registered at the clinic because of abdominal pains and diarrhœa of several years' duration. She had had symptoms typical of peptic ulcer for 20 years with several gastro-intestinal hæmorrhages during that time. Seventeen months previous to admission to the clinic, the abdomen had been explored, and although ulcer was not found gastro-enterostomy was done. She was free of symptoms for 6 months and then she had recurrence of the epigastric pain, somewhat to the right under the costal margin, which was less severe than that experienced prior to the operation. Food did not completely ease the pain. She had noted loose stools at intervals with undigested food particles in them. Melena had occurred approximately every 4 weeks since operation.

The hæmoglobin was 7.6 grams in each 100 cubic centimeters and the erythrocytes numbered 4,260,000. Total acidity of the gastric content was 48 and free hydrochloric acid was 30; 50 cubic centimeters was recovered. Roentgenograms of the stomach revealed a low gastro-enterostomy which was free with a long reversed loop. The pylorus was not patent.

At operation it was found that gastro-ileostomy had been done; the anastomosis in the ileum was midway between the duodenojejunal angle and the ileocæcal valve. The duodenum and intestine appeared normal. The gastro-enterostomy loop was taken down and the anterior half of the pyloric muscle was excised. The posterior wall of the duodenum was inspected but ulcer was not found. There was a slight fissure, irregular in shape and width, which bled easily on touch. This area was cauterized, the edges were sutured, and the operation was completed as gastro-duodenostomy. The pathological report was duodenal tissue with inflammation of the serosa. The patient recovered uneventfully.

CASE 6. A man, aged 31 years, came to the clinic complaining of daily vomiting of bile. He had lost 50 pounds in weight during the preceding year. He had had dyspepsia for 9 years with sour eructations, a sense of weight in the epigastrium, and pain after meals from which he obtained relief with soda. Fourteen months previously he had had severe colic-like epigastric pains, especially at night, with nausea, and later he had noticed blood in the stools. At that time a duodenal ulcer was found at operation and gastro-enterostomy was performed. The condition improved following operation but the patient began to vomit bile again in 2 weeks, and this persisted with the development of marked weakness. Exploration again a year later disclosed so many abdominal adhesions that nothing further was done. The bowels became irregular and loose, he vomited fæcal material, and gradually became weak and emaciated.

Examination revealed tenderness and spasticity of the epigastrium. Hydrochloric acid was absent in the gastric contents. At operation dense adhesions in the upper part of the abdomen were found. Gastro-enterostomy with the anastomosis in the ileum within 12.5 centimeters of the ileocæcal valve was found and was disconnected.

CASE 7. A woman, aged 43 years, a Russian Hebrew, had had abdominal pain for 3 years, followed by vomiting, nervousness, and marked constipation. It was difficult to obtain a satisfactory history. Thirteen months previously she had been operated on elsewhere and the gall bladder and appendix had been removed. Gastro-enterostomy was also performed for "an indurated area below the pylorus with marked stenosis." She had never been well since, complaining chiefly of nervousness, headache, belching of gas with a fæcal odor, "needle-like" abdominal pains, and diarrhœa. The bowels moved once or twice daily and several times a week she had from four to six loose stools.

Gastric analysis revealed total acidity of 38, and free hydrochloric acid of 24; 90 cubic centimeters was recovered. Roentgenograms of the stomach revealed a normal stomach and duodenum; the gastro-enterostomy loop was free and the anastomosis was apparently made low in the ileum. A barium enema did not show a fistula between the colon and the stomach.

A diagnosis of gastro-ileostomy was made and at operation the anastomosis was found to be 6 centimeters from the cæcum. There was no evidence of past or present gastro-duodenal ulceration. The anastomosis was disconnected and the patient recovered uneventfully.

CASE 8. A woman, aged 35 years, a Russian Hebrew, came to the clinic because of burning epigastric pain which had begun when she was aged 18 years. The symptoms were characteristic of peptic ulcer, occurring 1 hour to 1½ hours after meals. After 5 years of distress gastro-enterostomy was performed elsewhere. Four days after the operation profuse diarrhœa developed, consisting of ten to twelve stools daily (sometimes a stool every hour). The diarrhœa continued for 2 years, when the stools were reduced to four or five daily. The burning epigastric pain continued, and was not eased as completely by food and soda. She had lost 22 pounds in weight.

Examination disclosed tenderness in the abdomen above the umbilicus. The total gastric acidity was 22, free hydrochloric acid was absent, and the gastric contents amounted to 32 cubic centimeters. Roentgenograms of the stomach disclosed at first a free gastro-enterostomy, and a deformed duodenal cap. Subsequently the anastomosis was shown to be between the stomach and lower part of the ileum, permitting barium to pass almost immediately into the large bowel.

The patient refused to be operated on and further information concerning her has not been obtained.

CASE 9. A man, aged 32 years, came to the clinic because of "stomach trouble" of 10 years' duration. The symptoms were typical of duodenal ulcer and 1 year after the onset operation was performed. The nature of the operation was not known to the patient but presumably it was gastro-jejunostomy. Five months afterward the symptoms all recurred and to them were added hæmatemesis and melena. For six years intermittent periods of epigastric distress with ulcer characteristics had occurred. In 1924 a second operation was performed, the nature of which was not known to the patient. This was followed by relief of symptoms for a year and a half following which there was recurrence of pain and vomiting with some relief from alkalies and a bland diet. For several months he had experienced daily gastric distress associated with abdominal distention. A few days prior to admission he noted slight œdema of the feet and ankles and puffiness of the face and eyelids.

The patient was pale, and his abdomen was distended with fluid. There was moderate œdema of the scrotum, feet, legs, and face, and the reflexes were considerably reduced. The hæmoglobin was 67 per cent; the total gastric acidity was 80 and the free hydrochloric acid 70; 50 cubic centimeters was recovered. Roentgenograms revealed marked dilatation of the loops of the small bowel, apparently due to fluid in the abdomen. Tuberculosis was suggested by the roentgenologist. The urine contained albumin, graded 2, and a few casts. Ammonium nitrate and merbaphen were given and the anasarca disappeared. Cyanosis gradually appeared; this was subsequently shown to be due to transient methemoglobinæmia.

Because of the clinical diagnosis of recurrent peptic ulcer operation was performed. There was no evidence of free fluid in the peritoneal cavity. The gall bladder and liver were normal in appearance. The operation performed elsewhere had been gastrojejunostomy without suture of the opening in the transverse mesocolon to the stomach. As a result of this all of the small intestine had herniated through this opening, causing marked œdema of the bowel. To overcome this a second operation had been performed elsewhere, which consisted of anastomosis of the distended jejunum to the ileum 15 centimeters above the ileocæcal valve without reduction of the hernia. At the clinic the anastomosis between the jejunum and ileum was disconnected and the opening was closed. Examination of the existing gastro-enterostomy disclosed the presence of a jejunal ulcer. The hernia was reduced, the gastro-enterostomy loop disconnected, the jejunal ulcer excised, and the normal continuity of the gastro-intestinal tract restored. The patient's convalescence was fairly uneventful.

The essential data concerning these cases are summarized in the tabulation. It was found that the site of anastomosis in the ileum varied from the upper part of the ileum to within 5 centimeters of the ileocæcal valve.

INCIDENCE

A man, aged 44 years, and a woman aged 35 had gastro-iliac ulcers. In the one case in which gastro-ileitis was suspected of being present the patient was a man aged 39 years. Both the patients with gastro-iliac ulcers were Hebrews. The ages of the patients on whom gastro-ileostomy had been performed ranged from 31 to 44 years. In less than half the cases in which this operation was performed was there definite evidence of the presence of peptic or any other kind of organic gastroduodenal disease.

SYMPTOMS

Diarrhœa. This condition was present in all except 2 cases. The diarrhœa usually was lienteric, appeared almost immediately after the operation, and stools were frequent, occurring as often as once every hour. As a rule the stools occurred soon or immediately after meals, at times intermittently for a period of a few days but frequently persisting over long periods. Blood, mucus, or pus was not found in the stool. In the 2 cases of gastro-ileostomy reported by Carroll and Mercur, constipation was present although in one case lienteric diarrhœa occurred.

Diarrhœa following abdominal operations is usually to be regarded seriously, since the patient already weakened by the operation rapidly loses ground. The causes of such diarrhœa, as of other types, may be infections, and chemical and metabolic disturbances. Bargen and Rankin reported 12 fatal cases of ulcerative colitis following abdominal operation. The diarrhœa in these cases was usually preceded by a normal postoperative period of from 4 to 6 days following which abdominal cramps and diarrhœa developed. All but 2 of their patients were aged between 50 and 67 years. Younger persons apparently possess greater resistance to the disease. The diarrhœa occurring following gastro-ileostomy may be distinguished from that due to ulcerative colitis following operation because in the latter the diarrhœa is infrequently lienteric, is associated with blood and pus in the stools and with systemic evidences of infection.

It is also essential to distinguish the diarrhœa following gastro-ileostomy from that occurring in cases of gastrocolic or gastrojejunocolic fistula. The significant differential characteristics are the absence of typical pain of jejunal ulcer, usually to the left and below the level of the umbilicus, and the occurrence of the diarrhœa almost immediately following gastro-ileostomy. There is always an interval before the development of the jejunal ulcer and its perforation onto or into the colon. Lienteric diarrhœa and belching or vomiting of material with a fæcal odor may occur with either lesion.

Loss of weight. Almost all of the patients in our series lost weight, which is to be expected in the presence of lienteric diarrhœa. One might hope that there would be a definite relation between the nutrition of the patient and the level of the anastomosis in the small intestine, but such is not the case, probably for two reasons: (1) the pylorus often remains patent following gastro-enterostomy and a certain amount of food would still pass through normal channels, and (2) the compensatory processes of the body are such that exclusion or excision of a large portion of the small bowel is not incompatible with adequate nutrition.

Pain. There was no evidence that gastro-ileostomy in itself was productive of pain in any of the cases without secondary ulceration. Although in most cases the original epigastric distress of ulcer persisted after operation, in only 1 case was there any shift of the pain and this was toward the right and beneath the costal margin and perhaps downward. The 2 cases of secondary ileac ulceration are noteworthy because of the fact that the sec-

Fig. 1. A small deeply penetrating ulcer of the ileum 6 millimeters in diameter with an attached fibrinous exudate.

Fig. 2. The edge of the ulcer, and chronic inflammatory reaction, proliferating epithelium, and fibrinous exudate.

ondary ulceration was accompanied by the shift of the pain in 1 case to the lower part of the abdomen and in the other radiation of the epigastric pain into the back and both iliac fossæ. These pains had the usual ulcer characteristics. The shift of the pain in gastrojejunal ulceration is usually toward the left and to the level of or below the umbilicus. In gastro-iliac ulceration the pain apparently is shifted or radiated to the lower part of the abdomen, either in the median line, or else to both iliac fossæ.

Vomiting. It is of interest that vomiting to some degree occurred in almost every case. In 3 cases it was definitely fæcal and in one case gas with a fæcal odor was belched. The presence in the stomach of contents from the lower part of the intestine or colon may also be shown by gastric lavage.

DIAGNOSIS

The diagnosis of gastro-ileostomy should be relatively simple from the clinical history. If a gastro-enterostomy is followed almost immediately by intermittent lienteric diarrhœa without blood, pus, or mucus in the stools, with rapid loss of weight, possibly the vomiting of fæcal material, and absence of much abdominal pain, gastro-ileostomy or an equally faulty gastro-enteric anastomosis has probably been made.

In all but one of the present series of cases gastric acidity was low. This in itself, however, is not a diagnostic feature since gastric acidity is also usually low after gastrojejunostomy.

Roentgenological consideration of gastro-ileostomy may be diagnostic, as in some of the reported cases the anastomosis was so low in the ileum that the opaque meal passed rapidly into the cæcum. Secondary ulceration of the ileum is to be determined exactly as is secondary ulceration of the jejunum.

RESULTS AND COMPLICATIONS

The results of gastro-ileostomy may be divided into three groups: (1) mechanical, consisting of diarrhœa, vomiting, and loss of weight; (2) inflam-

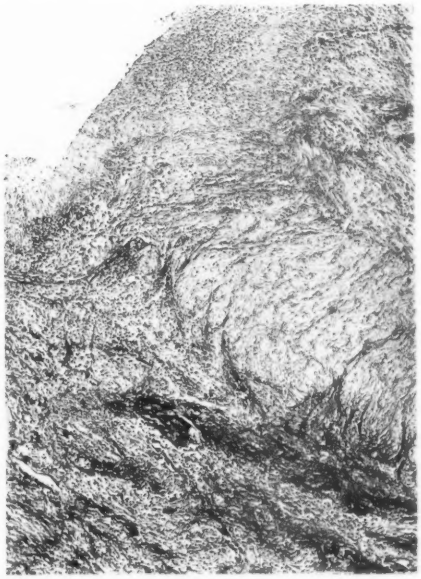

Fig. 3. Penetration of the ulcer through the muscle layer with marked chronic inflammatory reaction.

SUMMARY OF CLINICAL DATA

Case	Age, years, sex	Primary lesion	Anastomosis	Secondary ulcer	Time since operation, years	Symptoms	Acids		Roentgen-ray diagnosis	Operation
							Total	Free		
1	35 F	"Scar in duodenum close to pylorus"	Gastro-ileostomy, upper portion of ileum	Penetrating gastro-iliac (6 mm.)	0.6	Immediate onset of spells of diarrhœa lasting 2 or 3 days, 4 or 5 stools a day; loss of 20 to 30 pounds; pain in lower part of abdomen and epigastrium	50	30	Small gastrojejunal ulcer	Disconnection; excision of ulcer; partial gastrectomy; posterior Pólya.
2	44 M	Gastric ulcer	Gastro-ileostomy and jejuno-ileostomy, upper portion of ileum	Gastro-iliac	4	Epigastric pain with radiation to back and iliac fossæ	46	34	Gastro-enterostomy free, close to pylorus; small deformity of jejunum just opposite stoma	Disconnection.
3	39 M	Gastric ulcer	Gastro-iliac, more than 2.5 meters below duodenojejunal angle	Gastro-ileitis (?)	1.8	Immediate onset of stools of food, up to 10 a day; loss of 45 pounds; fæcal matter vomited	72	58	Duodenal ulcer; irregular stoma with dilated jejunum; gastrojejunal ulcer	Disconnection.
4	35 F	Duodenal ulcer (?)	Gastrojejunostomy and jejuno-ileostomy, just above cæcum		0.3	Diarrhœa after 3 months; loss of 92 pounds; fæcal matter vomited				Disconnection.
5	44 F	Ulcer history with hæmorrhage but no ulcer found	Gastro-iliac, midway between duodenojejunal angle and cæcum		1.4	Intermittent diarrhœa containing food; pain same as before operation, a little below and to right; some vomiting	48	30	Low gastro-enterostomy, free with long reversed loop; pylorus not patent	Disconnection and gastro-duodenostomy.
6	31 M	Duodenal ulcer	Gastro-iliac, 5 cm. above ileocæcal valve		1.2	Diarrhœa; loss of 50 pounds; fæcal matter vomited	10			Disconnection.
7	43 F	Indurated area below the pylorus	Gastro-iliac, 15 cm. from cæcum		1.1	Immediate onset of intermittent diarrhœa, 4 to 6 stools daily; epigastric pain ("needle-like"); fæcal gas belched	38	24	Normal stomach and duodenum; gastro-enterostomy free; anastomosis apparently made low in ileum	Disconnection.
8	35 F	Duodenal ulcer (?)	Gastro-iliac, lower part of ileum	?	1.3	Diarrhœa 4 days after operation; 10 to 12 stools daily for 2 years; loss of 22 pounds; epigastric pain as before operation; food only vomited	22		Anastomosis between part of stomach and lower part of ileum permitting barium to pass immediately into large bowel	
9	34 M	Duodenal ulcer	Gastrojejunostomy and jejuno-ileostomy, 15 cm. from cæcum	Jejunal	4	Œdema; epigastric pain; vomiting	80	70	Marked dilatation of loops of small bowel apparently due to fluid	Disconnection of gastro-enterostomy and jejuno-enterostomy and excision of gastro-jejunal ulcer.

matory, manifested as gastro-ileitis, and (3) ulcerative, manifested as ulceration of the ileum. These three groups are represented in the cases reported here. It would seem apparent from the case histories that entero-anastomosis with the stoma in the lower part of the ileum associated with gastro-jejunostomy as ordinarily performed acts considerably like gastro-ileostomy and produces the same effects.

In the majority of cases the effects of gastro-ileostomy were simply those of mechanical disturbances of gastro-intestinal activity which is readily understood. In 2 cases the disturbance in nutrition was so profound that the patients were unable to withstand the operative procedure of disconnection of the gastro-ileostomy loop.

Case 3 appears to be a good example of secondary inflammation of the ileum or gastro-ileitis, similar to gastrojejunitis following gastrojejunostomy (4). The presence of rather high gastric acids (total 72, free hydrochloric 58), the relatively large quantity of gastric contents (100 cubic centimeters) for a stomach on which gastro-enterostomy had been performed, the slight irregularity of the stoma and dilatation of the ileum on roentgenologic examination and the thickening of the stoma at operation, all pointed to the presence of a gastro-ileitis, although this could not be proved definitely in the absence of tissue for microscopic study.

Gastro-ileac ulceration. The occurrence of the ileac ulcer indicates that the ileum as well as the

stomach, duodenum, and jejunum, is susceptible to peptic ulceration. In each case the anastomosis was in the upper portion of the ileum and the pain was referred to the lower part of the abdomen. The pain these patients complained of was not so severe as is usual with gastrojejunal ulcer. It has been suggested that the lower part of the gastro-intestinal tract has a diminished sensitivity to pain impulses. Further evidence for this might be adduced from the fact that in the iliac ulcer coming under our observation the symptom of pain was less severe than that usually experienced with jejunal ulcer. Neither were the gastric acids so high as are ordinarily encountered in secondary jejunal ulceration. In both cases a diagnosis of gastrojejunal ulceration was made by the roentgenologist although in neither case was the clinical picture typical.

There is little clinical or surgical evidence that a duodenal ulcer was present in Case 1 before or after the original gastro-enterostomy, and the development of secondary ulceration in the small bowel is unusual since such secondary ulcers are rare except following gastro-enterostomy for peptic ulcer. In Case 2 the occurrence of ulceration of the ileum was hardly a prominent feature since there was an interval of 4 years between the original operation and the visit to the clinic. During the last of these years constipation was present and there was no loss of weight. This patient had a gastric ulcer, and it is known that secondary jejunal ulceration occurs relatively less frequently after gastro-enterostomy for gastric than for duodenal ulcer. These patients both presented clinical features which therefore should militate against the presence of secondary enteric ulceration.

Figure 1 shows the ileac ulcer in Case 1, a small deeply penetrating ulcer 6 millimeters in diameter with an attached fibrinous exudate overlying it. Microscopic examination (Figs. 2 and 3) disclosed a typical chronic penetrating ulcer of the ileum with little evidence of healing. There was considerable scar tissue in the base which had penetrated through the muscular layer and in which the walls of the vessels were markedly thickened. As the surface of the ulcer was approached considerable acute inflammatory reaction was encountered. Roentgenographic evidence of the ileac ulcer is shown in Figure 4.

Fig. 4. Roentgenogram in which arrows point to the crater of the ulcerated area in the ileum.

TREATMENT

The only satisfactory treatment for the unfortunate surgical error of gastro-ileostomy is the surgical disconnection of the anastomosis with re-establishment of the normal continuity of the gastro-intestinal tract. Additional operative measures may be necessary in the presence of organic disease independent of, or associated with, the anastomosis. Pre-operative treatment is important, since these patients are frequently dehydrated and undernourished as a result of diarrhœa and inadequate nutrition.

The stoma of gastro-enterostomy and entero-anastomosis should always be as high in the small bowel as is consistent with the lesion and which can be performed without undue tension on the intestinal loops. The short circuited loop should always be as short as is reasonably possible.

SUMMARY

The general characteristics of secondary peptic lesions which occasionally occur about a gastro-jejunal stoma can be reduplicated even to certain minute histopathological characteristics by similar lesions which may develop subsequent to the formation of anastomosis between the stomach or the jejunum and the lower part of the ileum.

Clinical evidence is suggestive that the potentiality for the development of peptic lesions arises whenever and wherever any segment of intestinal mucosa is exposed to the eroding action of the gastric chyme.

It would appear that a syndrome fairly characteristic for gastro-ileostomy can be formulated. If, following an operation performed for a gastric lesion, particularly if there is some evidence that a side-tracking operation had been attempted, the

patient begins to lose weight, to have lienteric diarrhœa, fæcal vomiting, and fæcal belching, and to lose weight rapidly despite normal appetite and normal ingestion of food, the suspicion should arise that an anastomosis has been made erroneously between the stomach and the ileum or colon. Similar symptoms may be produced by anastomosis between the jejunum and the ileum or colon.

If, following a period during which such symptoms have developed, pain is superimposed, and if this pain is situated lower than the original pain and arises from 30 minutes to several hours after meals, if it be referred downward or through to the back and is to any degree amenable to the ingestion of food or to the taking of an alkali, the presence of a gastro-iliac ulcer may well be suspected.

The surgical formation of gastro-ileostomy in itself may not be productive of definite symptoms, because in certain cases the pylorus remains patent and maintains its physiological function so that most of the food reaches the duodenum and the small bowel in the normal fashion, thus preventing emaciation, dehydration, and lienteric stools. The more the gastric contents leave the organ through the stoma, the more definite the syndrome of gastro-ileostomy will become.

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TREATMENT OF THE *FORME FRUSTE* TYPE OF PERFORATED PEPTIC ULCER [1]

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IN a previous issue of SURGERY, GYNECOLOGY AND OBSTETRICS we (8) described a particular type of ruptured peptic ulcer which distinguishes itself from the classical form in that the postperforative course is relatively brief and tranquil. It was pointed out that, whereas in the text book type of perforation, the manifestations following rupture are those of a diffuse, progressive inflammation, in the type described the symptoms correspond to a localized, receding peritonitis. It was furthermore stated that in the group under discussion the later in the course of illness the patient is observed, the more effaced and deficient is the clinical picture of peritonitis. In order to emphasize the mild and incomplete character of the perforative peritonitides in this particular group at the time patients generally present themselves for diagnosis, the term "*forme fruste*" was selected. The tranquillity of the postperforative course and the frequent, spontaneous recoveries in the *forme fruste* ruptures were ascribed to cessation of leakage due to spontaneous closure of the opening.

Since the prime purpose of the article was to call attention to the frequent occurrence and means of recognition of *forme fruste* perforations, merely this brief statement was made with reference to treatment: "If recognized within the first 24 hours, the patient with a perforation (*forme fruste*) is, as a rule, operated upon immediately regardless of the severity or mildness of the symptoms. In the event that the patient is not seen until the second day, i.e., between the twenty-fourth and forty-eighth hours after perforation, surgical treatment is practiced unless the symptoms and signs point indubitably to a spontaneous closure and trifling leakage. If there is any question as to the perforation being sealed, operation is insisted upon. After the first 24 hours, it is generally not difficult to decide whether the perforation is closed or not." The suggestion contained in this concise reference to treat without operation, selected *forme fruste* perforations when seen for the first time late in the course of the illness provoked rather sharp adverse criticism. From the nature of the objections advanced, it was clear that the commentators failed to take into account two important facts which serve to distinguish the *forme fruste* from the classical perforation.

They assume that spontaneous recovery following acute perforation is rare or unique and that unless surgically closed, a ruptured ulcer almost invariably leads to a fatal outcome. While this assumption is probably more or less true of the textbook type of rupture with unrestricted leakage, it does not apply to the *forme fruste* perforation where the escape of gastric content is usually merely trifling. In these mild cases the spontaneous closure of the hole promptly limits the intensity and extent of the peritonitis, and recovery frequently follows without surgical intervention. That spontaneous recuperation from acute perforation is by no means uncommon is attested to by the fact that in a recent survey at the Cook County Hospital 40 such instances were collected within a period of 18 months. The details of the individual cases and references to similar cases reported from other sources are contained in a previous communication (7). Further papers dealing with small series of cases of spontaneous recovery not contained in the article mentioned, have been published by Struthers, Van Amstel, Bruett, and Bager. Many single reports of recovery without operation, some of which were not recognized as perforations by their authors, can be added. Scrutiny of the facts connected with the individual cases of spontaneous recovery indicates that the perforation in a very large percentage is of the *forme fruste* type. We feel justified, therefore, in concluding that recovery from acute rupture of this mild type is a common occurrence.

A second fact which our critics fail to appreciate is that the *forme fruste* cases present in the postperforative stage a clinical picture which differs greatly from that of the classical rupture. A great many of the milder perforations, unless seen quite early, pass unrecognized and are handled medically under a mistaken diagnosis. Patients with *forme fruste* perforations are frequently erroneously considered to be suffering

[1] From the Department of Medicine, University of Illinois College of Medicine, and the Divisions of Medicine and Surgery of the Cook County Hospital. Read before the Chicago Surgical Society, May 1, 1931.

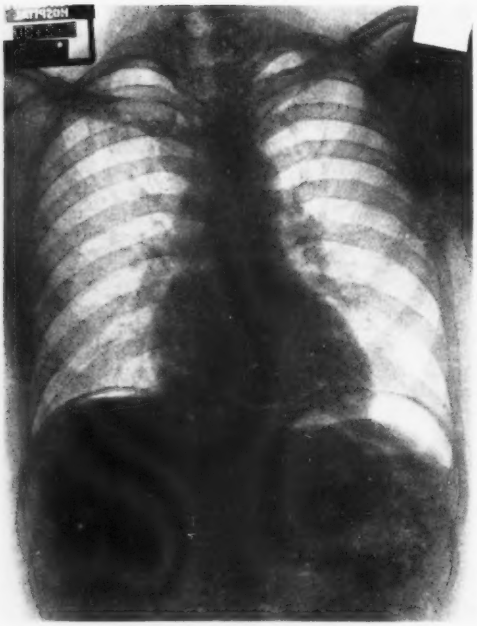

Fig. 1. Case 2. Roentgenogram taken 10 hours after acute perforation. The escaped air has collected beneath both domes of the diaphragm. A fluid level is seen below the gas bubble on the right. At operation the perforation was found to be sealed by fibrinous adhesions with the gall bladder.

from penetrating ulcer, coronary thrombosis, diaphragmatic pleurisy, cholecystitis, tabetic crisis, gastritis, colitis, pyelitis, etc., and accordingly are assigned to the internist for treatment. We do not hesitate to state that a great many of the *forme fruste* perforations, unless observed early, are misdiagnosed. In the case of ourselves, in spite of the fact that we have been seeing practically the same material for a number of years, it was not until recently that other than classical perforations were frequently diagnosed. In reviewing our older case histories of acute abdominal pain, we find a considerable number which in the light of our present knowledge appear in all probability to have been instances of *forme fruste* perforations which we overlooked. It is only since we have become more familiar with mild perforations through the use of the X-ray that we have come to recognize a typical clinical picture in the *forme fruste* cases. Even our clinical acquaintanceship and experience with *forme fruste* perforations proves at times inadequate in the light of X-ray "check-up."

Our impression of the frequent failure to recognize *forme fruste* perforations in the late postperforative course is further sustained by observations in our own and in other hospitals. The opportunity is not infrequently afforded us of examining patients previously studied by our colleagues. Our experience has been that, unless the attending surgeon is familiar with the clinical picture presented by mild perforations, he will usually fail to make the correct diagnosis. The appended case reports furnish representative illustrations of what occurs. The literature abounds in acute abdominal cases reported under various diagnoses which to us sound like unrecognized ulcer with relatively mild symptoms. The recent reports of Jenkinson and Ellis, and of Guimbellot furnish typical examples of failure on the part of the surgeon to discover the true nature of the illness not only before but at operation.

If the reader will endorse the views outlined above, an analysis will demonstrate that we are actually inclined more to operation in our treatment of perforated ulcer than the most radical of our critics. The seeming paradox can be explained quite readily. Classical cases we treat surgically according to current practice. *Forme fruste* perforations are invariably overlooked by our critics since they do not recognize the existence of this type. We operate upon them all, as a rule, if seen during the first 24 hours. The increased frequency with which operation for perforated ulcer is resorted to at the Cook County Hospital since the *forme fruste* type of rupture has been recognized as a nosologic entity is illustrated in statistical reports regarding the incidence of pneumoperitoneum in acute perforations. In a previous issue of this Journal (11) a report was published dealing with a series of 72 cases gathered prior to 1929 which were examined with the X-ray shortly after admission and in which the final diagnosis proved to be perforated peptic ulcer. Of the cases in which the diagnosis was not open to question, 85.7 per cent presented evidence of free gas. In a more recent statistical study which includes 35 cases observed at the Cook County Hospital during the first 11 months of 1929 Warfield found that of the proved cases, only 43.5 per cent were accompanied by a pneumoperitoneum. The discrepancy between the figures prior and subsequent to 1928 is due for the most part to the more frequent recognition of *forme fruste* perforations and to operation in a larger proportion of the acute ruptured ulcers which enter the hospital.

We are prompted to expatiate on the subject of treatment of *forme fruste* perforations because

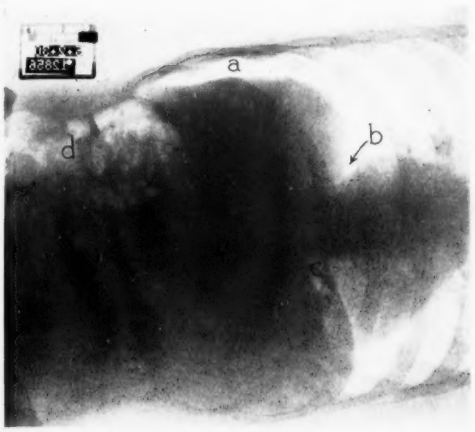

Fig. 2. Case 2. With the patient lying on the left side the free air in Figure 1 shifts to a position between the lower right ribs and the lateral border of the liver. Intraperitoneal air, *a*; air in the lung at the cardiohepatic angle, *b*; intragastric gas bubble, *c*; gas in ascending colon, *d*.

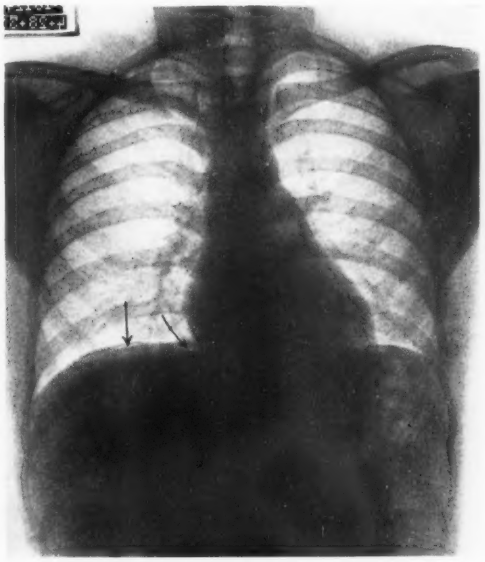

Fig. 3. Case 4. Roentgenogram taken 2½ days after perforation. The thin zone of intraperitoneal air (indicated by arrows) was the only clinical evidence at this time of a perforated viscus.

we anticipate misapplication of the knowledge that spontaneous recovery not infrequently occurs. With the more general use of the X-ray and more frequent resort to surgery in cases with abdominal pain of obscure origin, an increasing number of practitioners will note the tendency on the part of nature to seal or plug the perforation. We are fearful lest some physicians, after observing a case or two of recovery where operation for one reason or another has been omitted, will conclude that all acute ruptures which are not attended by fulminant symptoms can be treated medically with safety. As a matter of fact one can detect a tendency in this direction even at the present time. The literature contains reports of cases of "covered" perforations (Bondi, Falta, Wickbom) which we feel were surgical cases but which advertently were handled without operation.

It is a difficult matter to formulate any absolute rules with regard to the treatment of *forme fruste* perforations. There are cases in which the hole is plugged or covered almost immediately after perforation whereas in other cases spontaneous closure does not occur until a longer interval of time has elapsed and a moderate amount of leakage has ensued. Best results are obtained by basing judgment upon the clinical facts in each individual case rather than adhering rigidly to any proffered rule. The more experience the attending surgeon acquires the less reliance does he place upon a preconceived scheme. Generally speaking, the earlier the patient is seen after the moment of perforation the more difficult is it to decide as to the type of rupture present and the more desirable is prompt surgical intervention. The later in the postperforative course the patient is seen, the easier it is to judge the type of perforation present but the less satisfactory are the results accomplished by surgery.

For didactic purposes we have adopted the following arbitrary plan: Patients seen within the first few hours after perforation are almost invariably operated upon since at this early stage it is difficult or impossible to determine whether or not the rupture is firmly closed and leakage has ceased. The operative mortality is not over 4 or 5 per cent in these cases. Between the twelfth and twenty-fourth hours we generally operate, unless the evidence is quite clear that the peritonitis is closely limited and is in the stage of recession. Unless one has had considerable experience with the acute surgical abdomen, it is probably safer to explore all cases seen the first day following rupture. After the first 24 hours, sufficient time has elapsed in the average case to permit the surgeon to ascertain the extent and severity of the peritonitis, the state of the

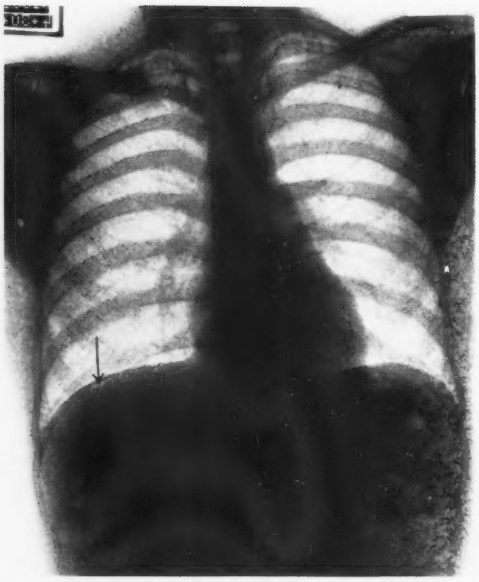

Fig. 4. Case 4. Film made 4½ days following perforation and 2 days later than Figure 3. The amount of free air (indicated by arrow) has decreased. Fluoroscopically the gas bubble was seen to shift with change of position.

Fig. 5. Case 4. X-ray appearance 6½ days after perforation. The roentgenogram was taken 2 days later than Figure 4. The intraperitoneal air has disappeared entirely.

perforation, whether closed or open, and the general course of the illness, whether retrogressive or progressive. If it can be determined *with a reasonable degree of certainty* that the hole is occluded, that the peritonitis is benign, and that the patient is well on the road to recovery, we are inclined to omit operative intervention, particularly since postoperative mortality at this time is high. After the second day following perforation there should be little, if any, difficulty in arriving at a decision. In a true *forme fruste* perforation seen for the first time on the third day of illness, the peritoneal inflammation has almost completely subsided, the general condition of the patient is excellent, and operation is, therefore, not required. It would only stir up more peritonitis and the hole when reopened might prove to be impossible to suture because of the friability of the tissues. After the third day of a *forme fruste* perforation the hole is generally effectively closed, and operative reclosure might be less secure.

We do not wish to enter at this time into any lengthy disquisitions regarding the ultimate fate of perforated ulcers where immediate excision, gastro-enterostomy, or gastric resection is not performed. It appears to us that the indication in the presence of a perforation aside from preventing further leakage is to combat the attending peritonitis. Any measure which serves no immediate purpose and which adds to the length of the operation or enhances the spread of the peritoneal infection seems hardly justifiable. When and if the patient survives the peritonitis, the ulcer can be dealt with at a time when the operative risk is not nearly as great.

There are two dangers connected with non-operative treatment of *forme fruste* perforations. The first and more serious is reopening of the closed aperture and the second is intra-abdominal abscess formation. With regard to reperforation our experience has been that secondary leakage seldom occurs. Although we have been constantly on the alert for it we have failed to observe any case in which reopening of the hole developed during the course of observation. Even where a *forme fruste* perforation had not been recognized and a patient had been given fluids including milk by mouth, the feared breaking of the seal seldom followed. Although the hazard from the practical standpoint we believe to be not great, we nevertheless observe all precautions possible to prevent further leakage. If the fluoroscopic examination shows the stomach to contain a con-

siderable amount of fluid, an Ewald tube is introduced and the gastric contents are siphoned off by gravity. The patient is then instructed to lie on his left side. In this position any fluid present gravitates to the fundus and the gastric air rises to the pylorus where more than 90 per cent of the perforations occur. Should some of this air leak out, the X-ray will discover it and thus furnish an immediate operative indication. Nothing is given by mouth for 3 days or more, fluids being given rectally and by hypodermoclysis. Modified Sippy is then used.

We have been confronted with very few perigastric or other intra-abdominal abscesses following unoperated upon *forme fruste* perforations. It appears to us that the incidence of persistent localized suppuration is no less in the operated upon than in the unoperated upon *forme fruste* cases. The peritoneum it seems has little difficulty disposing of a limited amount of gastroduodenal leakage, particularly when the hole is a small one and only liquid material escapes. In all but the exceptional case the patient becomes afebrile within a few days following a *forme fruste* perforation. Persistence of fever for more than 3 or 4 days is looked upon as evidence of intra-abdominal suppuration and demands close attention. Spontaneous absorption usually occurs. Sticking pains felt upon stretching or sudden change of position are complained of not infrequently for several weeks after perforation. It should be pointed out that the danger of intraperitoneal abscess formation and consequent secondary spread is very great in cases which are not strictly of the *forme fruste* type. It is, therefore, hazardous to delay surgery unless the evidence for a mild perforation is quite clear.

The appended case reports selected from a rather large number are representative of the group of perforations under discussion and illustrate the following points: (1) At the time a patient with a *forme fruste* perforation generally reaches the hospital the classical picture of a ruptured ulcer (with board-like rigidity, etc.) is lacking. (2) Unless the examiner is cognizant of the mildness of the postperforative manifestations in the *forme fruste* type, the presence of an actual perforation is generally overlooked. (3) A detailed, minute-by-minute history of the onset together with a knowledge of the course of the illness usually leads to a correct diagnosis even in the absence of the accepted physical findings of perforated ulcer. (4) When the patient is seen for the first time late in the course of illness, it is relatively easy in the average case to decide whether or not surgery is advisable.

CASE 1. *Forme fruste* perforation recognized 7½ hours after onset. Operation. Recovery.

R. G., a white man of 50 years, entered the Cook County Hospital on May 19, 1930, at 5 p.m. on account of severe, upper abdominal pain. The history states that the patient was perfectly well until 4 hours preceding admission when, while walking rather hurriedly, he was seized with severe epigastric pain which caused him to stop immediately. The onset of pain was followed by a profuse sweat and the fear that he would die before arriving home. With difficulty he succeeded in reaching his destination which required a half hour's travel on the street car. He called his physician who diagnosed coronary disease, administered a hypodermic, and advised hospitalization.

Upon hospital entrance there was tenderness and rigidity in the right side of the abdomen and in the epigastrium. The rectal temperature was 99.2 degrees F., the pulse rate 92, and the respiratory rate 22. At the time of entrance the patient was quite comfortable except for soreness in the upper abdomen. The diagnosis of acute cholecystitis was made by the examining surgeon.

We saw the patient at 8:30 p.m., which was 7½ hours after onset. By inquiring into details the assertion was elicited that 4 weeks before entrance the patient began to notice epigastric, gnawing pain which led him to eat at least five times a day. He said he experienced heartburn only once during these 4 weeks. A week prior to admission tarry stools were observed. The day of onset of his acute symptoms he noted nothing unusual until 1 p.m. when he was suddenly seized with such severe pain that he "doubled over." The pain spread throughout the upper abdomen and radiated to the back and to the right shoulder. It required all his reserve strength and courage to mount the street car, tolerate the agony experienced during the ride, and to walk a block after alighting from the car. Without disrobing he threw himself on the bed and ordered his wife to summon a physician immediately. Following the hypodermic, the pain moderated to such a degree that were it not for the insistence of the family doctor who predicted subsequent attacks the patient would not have consented to hospitalization.

The diagnosis of *forme fruste* perforation was made and operation recommended. The fluoroscopic examination undertaken en route to the operating room failed to disclose the presence of free air. Before laparotomy the stomach content was siphoned off and about 200 cubic centimeters of a brownish material with an alkaline reaction was obtained. When the peritoneum was opened there was seen a moderate amount of fibrin in the upper abdomen mainly on the right side. The pyloric region and duodenum were covered by the liver. By gently raising the liver it could be seen that its under surface was adherent to the anterior duodenal wall. When the loose adhesions were separated, a 4 millimeter perforation located on the anterior wall of the duodenum was disclosed. There was slight induration spreading beyond the margins of the rupture. The hole was sutured and covered by an omental flap. Recovery was uneventful.

CASE 2. *Forme fruste* perforation diagnosed 13½ hours after onset. Operation. Recovery.

F. W., a white man of 22 years, entered the hospital May 2, 1930, at 2:30 a.m. on account of acute abdominal symptoms. The suspicion of a surgical abdomen was entertained by the admitting physician but the patient did not appear "sick enough" to warrant a positive diagnosis. The history obtained by the house physician reads as follows: "For the past week the patient has been troubled by costiveness which occasioned resort to various cathartic pills without benefit. On May 1, 1930, at 10:30 p.m., following ingestion of part of his supper, the patient felt

rather faint. Shortly after the appearance of the faintness he was seized with epigastric pain which felt as though his 'intestines were being knotted up.'" This sensation lasted for half an hour after which time it subsided and was replaced by a soreness felt throughout the abdomen. Vomiting occurred half an hour after the onset of the pain and was induced by digital irritation of the pharynx. No history of any previous gastro-intestinal disturbance was recorded. The temperature at entrance was 99.4 degrees F., the pulse rate 74, the respiratory rate 20. The blood pressure was 130—90. The physical observations on the chart include moderate tenderness and very slight rigidity over the right side of the abdomen, especially in the right lower quadrant. The blood count was 14,050. Cathartic colitis and appendicitis were suggested by the attending surgeon.

When we saw the patient in consultation at about noon, 9½ hours after admission to the hospital, we were able to elicit the following information relevant to the onset of the illness: The patient, who worked nights, had suffered from no epigastric distress prior to the onset of his present acute illness. On the evening of onset he ate only half of his usual meal on account of lack of appetite. At 10:30 p.m. because of faintness he went outdoors to obtain fresh air. He had hardly walked 50 feet beyond the factory when he was seized by a severe pain which caused him to fall to the ground and to writhe about in extreme agony. He remained stricken for a few minutes before he could manage to rise and walk to the factory from which he was carried to an emergency hospital. Within a half hour the severe pain had subsided spontaneously. The patient thought that he was suffering from a "stomach-ache" related to his constipation and when the doctor arrived and advised hospitalization the patient hesitated. En route to the hospital the patient felt quite comfortable and practically had no complaint after entrance.

From the history of sudden onset of violent pain and from the physical evidence of tenderness and rigidity on the right side of the abdomen together with a leucocytosis, we suspected the presence of a perforated ulcer which had become sealed over. By means of the X-ray (Figs. 1 and 2) a pneumoperitoneum was demonstrated and the diagnosis of perforation thus confirmed. At operation there was found a small quantity of yellowish fluid and a moderate amount of fibrin noted in the upper abdomen. The fundus of the gall bladder was attached to the first portion of the duodenum by recent fibrinous adhesions. Moderate traction which led to separation of the adhesions showed that the gall bladder formed the base of a recent duodenal ulcer with a 5 millimeter perforation. The hole was sutured and covered with omentum, following which the patient made an uneventful recovery.

Case 3. *Forme fruste* perforation first detected 23 hours after onset. Not operated upon, contrary to the general rule, on account of the extreme mildness of symptoms. Recovery.

J. C., a known ulcer patient, 30 years of age, entered the hospital August 20, 1930, at 1 a.m., 3 hours after the occurrence of acute abdominal pain. Twenty-three hours later we were apprized of the case and found the following information relative to the acute illness recorded in his chart: Four hours after the evening meal of August 19, 1930, the patient noted epigastric distress which gradually increased in intensity, reached its acme within about half an hour, and then traveled to the right lower quadrant. The patient vomited what he had eaten and went into a state of collapse although he did not lose consciousness.

Upon admission, the temperature was 99.4 degrees F., the pulse rate 108, and the respiratory rate 24. The blood pressure was 122—90. There were tenderness and rigidity over the right upper rectus and over McBurney's point. Rebound tenderness was referred to the right lower quadrant. The diagnosis of penetrating ulcer was made and receding acute appendicitis considered as a possibility.

A minute-by-minute inquiry by us yielded the following detailed account: On August 19, 1930, at 6 p.m. the patient ate a meal consisting of boiled meat, potatoes, carrots, pudding, and tea. At 10:00 p.m. he experienced dull epigastric pain associated with a sense of heaviness and distention. He then took a magnesia powder in spite of which the pain gradually increased in intensity and became sharp and knife-like, aggravated by deep breathing. He found it necessary to double forward and was flexing more and more when suddenly he was seized by violent pain which caused him to cry out. He developed a cold sweat, felt faint, then vomited and became somewhat dazed. He was assisted to bed where he lay groaning for about 10 minutes, squirming about in extreme agony. After this time he resumed the recumbent position cognizant of a dull pain involving the right hypochondrium. The intensity of the pain at onset impelled him to order his wife to summon a doctor who arrived just 45 minutes after the pain began, but at this time, the patient was fairly comfortable. The doctor was perplexed and suggested hospitalization.

When the patient arrived at the hospital shortly after midnight he felt no actual pain, although he chose a semirecumbent position. The admitting physician questioned the need of hospital care but finally decided to assign the patient to a medical ward with the diagnosis of penetrating ulcer. That night the patient slept poorly on account of the strangeness of the bed rather than pain of which he had practically none. During the day he received three glasses of milk. He had some epigastric gnawing but no sharp pain. When seen by us that evening tenderness could be elicited in the right upper and lower quadrants, but at this time the patient had no spontaneous pain. The diagnosis of a *forme fruste* perforation seemed probable. The fluoroscopic examination showed a very small collection of air, just beneath the right diaphragm. The following day X-ray plates were ordered but failed to show the presence of a pneumoperitoneum.

Upon our recommendation, the patient received no food for 2 days, following which Sippy treatment was begun. X-ray with a barium meal on September 5, showed a constant duodenal defect, characteristic of ulcer. On September 6, 1930, the patient was discharged feeling entirely well. No further symptoms have developed to the present time.

Case 4. *Forme fruste* perforation discovered 40 hours after onset. No operation. Recovery.

C. M. a white man of 23, was admitted to the Hospital, April 27, 1931, at noon with the admitting room diagnosis of subsiding appendicitis. The history of diffuse abdominal pain localizing to the right lower quadrant together with tenderness and rigidity over McBurney's point led the house physicians to accept the original diagnosis of appendicitis.

By pertinent questions we succeeded without any particular difficulty in obtaining the following history: For several months the patient had experienced, following meals, a discomfort which was relieved by food and by soda. On April 25, 1931, he perceived the usual postprandial distress except that following the evening meal the discomfort was more persistent than usual. At 10 p.m. that day he was seized suddenly by an extremely violent epigastric pain which within a minute or two had spread to involve the entire abdomen. He flung himself on a bed and tossed about seeking a position of comfort but without avail. Medication which was administered was immedi-

ately vomited. The pain continued intense until about 2 the following morning (April 26) when it became tolerable. At 4 a.m. the patient fell asleep and awoke at 9 a.m. with abdominal "soreness." He was given a fluid mixture containing peppermint which he retained. He arose but returned to bed after half an hour as movement caused pain. At noon he went to the table and drank a bowl of soup. He returned to bed and arose again at 5 p.m. when he had a second bowl of soup and two glasses of water. That evening, April 26, which was the day following rupture he remained up and about conversing freely with friends. He retired at the usual time, slept well, arose the following morning (April 27) and ate a fair helping of gruel. Later in the morning, because he was still weak and some degree of soreness persisted, he decided to go to the hospital.

Upon admission which was 38 hours after the onset of acute pain his temperature was 101 degrees F., the pulse rate 100, and the respiratory rate 24. The patient appeared quite comfortable and did not give the impression of being at all ill. As a matter of fact when we first saw him 2 hours later he was partaking of and seemingly enjoying some soup and milk which were inadvertently served him. The physical observations consisted of slight tenderness and rigidity on the right side with some diminution in peristaltic activity. The respirations were abdominal in type and unrestricted. No shifting tympany obliterating the normal liver dullness could be demonstrated. Fluoroscopic examination disclosed the presence of free air in the abdominal cavity.

It was apparent that the patient had suffered from a ruptured ulcer. However, because of the mildness of the symptoms and the limitation of the peritonitis, it was believed that the perforation had closed spontaneously. The fact that the patient had ingested fluid without any ill effect led to the assumption that the closure was a secure one. The patient was instructed to remain on his left side, the gastric contents were siphoned off and proctoclysis was instituted. The following day, April 28, 1931, the patient felt and looked well and was entirely free from pain. There was very slight tenderness in the right upper quadrant elicited only upon deep pressure. The highest temperature recorded that day was 100.4 degrees F., the maximum pulse rate was 76. The general condition of the patient appeared so satisfactory it was felt that a radiographic examination could be undertaken with impunity. The X-ray film (Fig. 3) taken April 28, showed a slight diminution in the quantity of intraperitoneal air as compared with the amount noted fluoroscopically on the previous day. Daily radiograms showed a gradual absorption of the escaped air (Fig. 4) until May 2, 1931, when all evidence of a pneumoperitoneum was seen to have disappeared (Fig. 5).

On April 29 (3½ days following perforation) no signs of illness were detected. The temperature, pulse, and respiratory rates became and remained normal. On April 30, fluids by mouth were started. On May 4, the patient was up and about and on May 6, was discharged feeling quite well. He returned for a barium meal study on May 15, 1931, when a duodenal deformity significant of ulcer was demonstrated. The excursion of the diaphragm was not restricted.

CASE 5. *Forme fruste* perforation first observed 3½ days after onset. No operation. Recovery.

A. O., a white man, aged 39 years, was admitted to the Cook County Hospital October 13, 1930, complaining of previous periodic attacks of abdominal pain and vomiting. The temperature was 99 degrees F., the pulse rate was 100, and the respirations 24. Physical examination showed evidences of tabes dorsalis (including Argyll-Robertson pupils), a scaphoid abdomen, and tenderness on the right side, especially in the upper half. There were also physical signs of an active tuberculosis in both lungs. To account for the abdominal symptoms the diagnosis of gastric crisis was made and accordingly anti-luetic treatment was prescribed. An assertion made by the patient to the effect that soda had afforded some relief during previous attacks served to cast doubt upon the accuracy of the diagnosis mentioned and to occasion our interviewing the patient on October 14, 1930, 3 days after onset.

By careful inquiry and cross-questioning we obtained an account of periodic attacks of epigastric pain of the ulcer type associated with vomiting. The symptoms would cease spontaneously, after which the patient would feel well until the succeeding attack appeared. The last recrudescence began a month or so prior to entrance, on which account a physician who was consulted prescribed a milk and cracker diet and powders after meals, with some relief.

On October 11, 1930, 2 days before admission the patient was awakened from sleep at 3 a.m., by a most agonizing pain located in the epigastrium and right hypochondrium. He writhed about yelling for aid but was unable to arouse his neighbors. Finally he assumed a fixed supine position with his right thigh flexed upon his abdomen. Motion as well as palpation elicited sharp pain referred to the right side. By 7.00 a.m. the patient had sufficiently improved to leave his bed and to summon a neighbor who was requested to fetch a quart of milk. The patient drank the entire amount, immediately following which vomiting ensued and the pain recurred. The pain continued severe for 3 hours, after which it abated.

The patient felt fairly well after 10:00 a.m. except for abdominal soreness. He stated that he would have gone to work at noon were it not for his inability to straighten up without resultant pain in the upper abdomen. He was physically able, however, to go to the restaurant for milk and crackers. The following day, October 12, he was still incapable of walking erect. On October 13, the patient went to work, but finding himself physically unfit he decided to come to the hospital to convalesce.

We saw the patient for the first time on October 14, which was 3 days after the onset of acute pain. The last note recorded by the nurse previous to our examination read: "Temperature, 98 degrees F.; pulse, 88; respiratory rate, 20. Slept well all night. Offers no complaint. Cheerful." We were able to elicit moderate tenderness in the right hypochondrium and slight tenderness over the right iliac fossa. The X-ray failed to disclose the presence of a pneumoperitoneum. An infiltration was noted in both upper pulmonary lung fields. The Wassermann test on the blood had been returned 3 plus, and on the spinal fluid 4 plus. We considered operation for the purpose of closing the perforation unnecessary at this time and on account of the tuberculosis and syphilis we deemed surgery inadvisable. The patient's abdominal symptoms subsided on conservative management. A subsequent X-ray examination with barium showed a duodenal deformity characteristic of ulcer. The patient was subsequently transferred to the tuberculosis ward entirely free from abdominal complaints.

SUMMARY AND CONCLUSIONS

In treatises on perforated ulcer, it is generally stated that spontaneous closure of perforation seldom occurs. On the basis of this assumption the logical conclusion with regard to treatment is to operate upon practically every ruptured

ulcer whenever seen, early or late, in order to prevent further escape of gastroduodenal content. The premise that practically all perforated ulcers, unless surgically closed, lead to a fatal outcome is incorrect as it fails to take into account a group of cases, the *forme fruste*, in which there is usually early, spontaneous closure of the hole following a minimal amount of leakage. Since, in a large proportion of these cases when seen late, the hole is obviously closed and the peritonitis is subsiding, operation can accomplish little or nothing of benefit and may do harm.

Our present plan of treatment for these *forme fruste* perforations is as follows: Practically all patients seen within the first 24 hours of onset are operated upon, since in the early stage it is difficult or impossible to determine whether or not the rupture is firmly closed and leakage has ceased. When the patient is seen for the first time during the second 24 hours and it can be determined with a reasonable degree of certainty that the perforation is securely sealed and the peritonitis is limited and receding, we are inclined to refrain from surgical intervention. If there is any doubt as to the closure of the perforation, immediate operation is employed. If the patient is first seen after the second postperforative day, it is generally a simple matter to decide whether or not spontaneous closure with only insignificant leakage has occurred. A peritonitis which is still diffuse and active at this time indicates that the perforation is not of the *forme fruste* type.

In the non-surgical treatment of the late *forme fruste* ruptures, the stomach when distended with fluid is aspirated by siphonage, the patient is required to lie continuously on the left side, and food and fluids by mouth are withheld for 3 or 4 days or even longer. Fluids are furnished by proctoclysis and hypodermoclysis.

The treatment described does not differ greatly from that generally employed at present by other internists and surgeons since *forme fruste* perforations unless seen very early are not recognized by most of the members of the profession. An erroneous diagnosis of a non-surgical ailment is usually made and the patient treated accordingly. Due mainly to the increasing familiarity with *forme fruste* perforations, a far greater proportion of perforated ulcers are operated upon at the Cook County Hospital now than heretofore.

We wish to sound a note of warning against the indiscriminate application of the principles of treatment set forth in this article. The recommendations submitted here apply exclusively to *forme fruste* perforations. The presence of only slight or moderate improvement during the first 24 hours does not constitute proof of a *forme fruste* rupture or indicate that leakage has been completely checked. Unless the recovery from the peritonitis is almost complete, a *forme fruste* perforation cannot be assumed. If one cannot be reasonably certain of the type of perforation present, the case is best treated according to accepted current teaching.

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TRANSPLANTATION OF TENDONS WITH STABILIZATION OF PARALYTIC TALIPES

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POLIOMYELITIS has probably been with us since earliest times as suggested by incidences described in some of the carvings of Egypt's pyramids, in biblical history, and by the deformities occurring in some of the famous characters of our more recent history. However, it was not until 1793 that the first description of the disease appeared in medical literature. In 1840, Heine presented the first systematic study of the condition and since that time we have been confronted by this serious epidemiological and therapeutic problem. It is not the intention in this short paper to go into the various phases of prevention of the disease, early treatment of active cases, or treatment of the various types of deformities occurring with inefficient care but to deal with a rather interesting portion of the surgical management of the residual paralytic involvement of the feet.

In a brief way, the nature of the disease is that of an acute onset of some fever accompanied by disturbances of the gastro-intestinal, respiratory, and excretory systems, sweating, meningeal irritation, hyperæsthesia and pain, with the development of a flaccid type of paralysis of an irregular distribution. This paralysis may involve practically the entire body or any portion of it. The hyperæsthesia of the skin surfaces and along the nerve roots, etc., together with tenderness to pressure on the muscles on manipulation of the extremities may be mild or so severe as to cause excruciating pain upon the least disturbance. As the symptoms subside, the pain and hyperæsthesia diminish, and the paralysis begins to clear up in an irregular manner. When the tenderness has disappeared, physiotherapy in the form of heat, gentle massage, and active exercises under proper supervision, aids temporarily paralyzed muscles to regain all or a portion of their strength up to a certain point. The training of active muscles increases the power in those which have been left weakened and educates some of the more powerful ones to take over, to some extent, the physiological function of those permanently paralyzed. Carefully guarding extremities from the development of deformities by the judicious use of splints and braces accompanied by muscle training over a period of a year and, preferably, 2 years, assures one that he has obtained the maximum possible recovery. This is spoken of as the residual or stationary stage, and active measures designed to rid older children and adults of their appliances are next in order. As the purpose of this paper is to deal entirely with paralysis involving the feet, all procedures referred to will be governed by the facts that they are weight bearing members, and, in order to function efficiently, stability must be the prime consideration. Useful motion is very desirable but must take second place to weight bearing stability.

Muscular imbalance in a weight bearing extremity combined with the forces of gravity and static influences leads to the development of deformities, the degree of which is in direct proportion to the extent to which the conditions already enumerated exist. Completely paralyzed or flail extremities are deformed by gravity and static influences entirely. Untreated or improperly treated cases of infantile paralysis are almost without exception complicated by the development of more or less severe deformities interfering with the recovery and function of what muscles remain physiologically active. One should not relegate the case to the "residual paralysis" group until he has instituted physiotherapy and protective measures for a period following the correction of existing deformities. Stretching of some muscles by virtue of the malposition of the extremity frequently leads to a temporary paralysis of a fatigue type and, following correction, a surprising amount of recovery of muscular power occurs. The importance of proper protection in splints and braces as a means of the prevention of deformities and of assisting in the recovery of muscle power cannot be too strongly urged.

Inversion or varus, eversion or valgus, equinus, calcaneus, and combinations of these positions are the common types of deformities seen. Paralytic talipes valgus and talipes calcaneus are probably the most frequent deformities found in the residual stage due to the fact that the anterior tibial muscle and the calf muscles are the ones most frequently involved and least frequent in incidence of recovery. Following closely upon these deformities are those of varus due to loss of power in the peroneal group. A cavus or "hollow foot" is frequently found when power is retained

in the peroneal and posterior tibial muscles in absence of power in the calf muscles. As the sequelæ of this muscular and static imbalance, various bones in the feet become abnormally prominent and callosities develop upon these prominences due to the pressure of shoes or braces when weight bearing is undertaken. As has been mentioned by various writers, many people walk better with artificial limbs as they are not sufferers from the pain of heavy callosities developed upon lateral deformities. There is no reason why paralytic feet cannot be made as stable, from a functional standpoint, as are artificial feet and still retain more flexibility.

About 1882, Nicoladoni reported the transplantation of the peroneal tendons for the relief of calf muscle paralysis and sounded the opening note for the modern conception of tendon transplantation. The idea was not a new one, but his report gave new life to an interesting phase of the surgery of paralytic deformities. Drobnik published an article in 1896 dealing with the transplantation of tendons to new locations usually transplanting them into the periosteum. A wave of enthusiasm developed and many surgeons attempted operations of a similar type with more or less success. Among the many surgeons helping to popularize this type of operation we find Lange, Vulpius, Mueller, Jones, and others. Nicoladoni's method which was one of tendon-to-tendon anastomosis was taken up and perfected by its ardent supporters, Vulpius and Codivilla, while Drobnik's method of periosteal fixation was perfected by Lange and the idea used in other methods as described by Wolff, Mueller, and others. All of these methods refer primarily to the fixation of the transplanted tendon, whereas Biesalski and Mayer, viewing the problem from a different aspect, conceived of the necessity for more careful preservation of the gliding mechanism of the tendon to be transplanted. They passed the healthy tendons through the sheaths of the paralyzed ones, utilizing the gliding mechanism of paratenon and mesotenon present to improve the functional results.

The earlier methods based purely on mechanical lines, as little if any attention was given to the physiological factors present, could not survive. With more study and the mistakes in judgment leading the way, modern methods based on physiological and biological principles were developed. Biesalski and Mayer should probably be credited with opening up this new aspect.

Careful studies on the histological structures of the tendon and its gliding mechanism such as those mentioned above and those made by Lovell and Tanner, Bernstein, and others have changed the entire conception of the tendon transplantation problem. Tendon nutrition, nature of gliding action, the preservation of the gliding mechanism with the prevention of adhesions between transplanted tendons and surrounding structures have been carefully studied. The evaluation of power in muscles proposed for transplantation and their mechanical efficiency, the effects of the strain of weight bearing, and the prospects of obtaining satisfactory stability were problems requiring careful consideration.

Several principles to be followed in the choice of muscles suitable for transplantation have been laid down. It is felt that one should briefly enumerate these principles. First, a muscle should have a similar or, at least, a related action to the one to be replaced and must be treated with its tendon and gliding mechanism, etc., as a unit and utilized as such. The method of splitting of tendons and the insertion of the parts into different points has proved unsatisfactory, as the muscle and tendon form one unit acting as a whole and portions of the unit cannot be expected to produce antagonistic action by giving them two separate insertions. An antagonistic muscle can be used as a replacement for a paralyzed opponent but long periods of training are necessary to get properly conditioned nerve paths to ensure smooth efficient action.

Second, the strength of the muscle to be transplanted must be nearly that of the one which is to be replaced. Third, the line of pull from the muscle origin to tendon insertion should be as straight as possible. Maximum efficiency cannot be expected if there is an angulation in the line of pull of the muscle. In the fourth principle, we have one of the greatest problems, namely, the proper tension to be placed on the muscle when the tendon is fixed at the new point of insertion. If the tension is too great, fatigue occurs followed by atrophy of the muscle fibers; if not great enough, the muscle is inefficient because part of its range of contraction is utilized in taking up the slack in its tendon. Fifth, careful attention must be paid to the preservation of the gliding mechanism of the tendon as a means of preventing the formation of adhesions and of supplying nourishment to the transplanted tendon. Anatomico-physiological studies have been made by Biesalski and Mayer, Lovell and Tanner, Bernstein, and others, and these have previously been referred to. As a result of the efforts of these authors, the physiological methods of tendon transplantation have been developed. Many operations have been described based primarily upon the preservation of the peritenon and

mesotenon, and the reconstruction of the tendon sheaths. In transplantation mentioned by Lange and others, the tendon has been isolated from its sheath and passed through the subcutaneous tissues. Poor results have been obtained due to the early formation of adhesions. In many of the transplantations about to be reported here, this method has been used in conjunction with subtalar arthrodeses, and the results obtained have been satisfactory.

Biesalski and Mayer describe the transplantation of tendons through the sheaths of the paralyzed muscles with much better results. This method has not been used because with arthrodesis of the tarsus the points chosen for the new insertion of the tendons have not coincided with any available sheaths.

Transplantation of the tendon plus its sheath as a unit as mentioned by Bernstein has not been tried in any of these cases. Sixth, all deformities must be corrected before transplantation is undertaken. Weaker by virtue of mechanical embarrassment due to its new position the transplanted muscle cannot be expected to correct deformities which have probably been present for months or years. Seventh, anchoring the transplanted tendon furnishes ample opportunity for the exercise of ingenuity on the part of the operator. The many methods of tendon transplantation described have all laid emphasis on the insertion of the tendon until the advent of the more recent physiological aspects. To attempt to describe these methods is unnecessary as they are so ably described by their supporters. The subperiosteal fixation of the transplanted tendon has received greatest support, and, in the cases to be reported here, all transplanted tendons have been fixed subperiosteally as mentioned by Wolff or transosseously as mentioned by Mueller.

Tendon-to-tendon anastomosis as described by Nicoladoni and Vulpius has been used very satisfactorily in the upper extremity but is looked upon with disfavor in the lower extremities, with one exception. The exception referred to is the method described by Royle for transplanting the posterior tibial or peroneal tendons into the tendo achillis to add to the strength of the calf muscles. The transplanted tendon is stripped of its gliding mechanism for a short distance, split longitudinally, and the two halves laced back and forth through the Achilles tendon so as to interlock the one through the other. It is almost unnecessary to use sutures to make the transplanted tendon secure.

In many cases, the operator, in his enthusiasm, has lost sight of the indications mentioned which govern transplantation and, as a consequence, unsatisfactory results have been the outcome. Steindler, in 1919, reported a series of 48 cases of transplantation of tendons in the feet with satisfactory results in 75 per cent of cases. This report was very encouraging compared to those published by other authors. By a satisfactory result is meant stability on weight bearing, permanent prevention of lateral deformity, and more or less active function of the transplanted tendon in the line of action of the paralyzed tendon.

In spite of good results reported by a few surgeons, tendon transplantation in itself was proving to be a disappointment in that instead of being a solution for a difficult problem in weight bearing stability it was being represented by poor or bad results. It was little wonder that the question of the practicability of tendon transplantation was raised, and in 1922 the American Orthopedic Association appointed a committee headed by Cook and Stern to study and report on the problem of stabilization of the feet. Most of the feet examined by the commission had been subjected to operation upon the soft parts. Tenodeses, tenotomies, or tendon transplantations had been done, but eventually it had been necessary to perform some operation upon the bones in order to obtain satisfactory stability. It was the opinion that transplantation of tendons should be used only in connection with stabilizing operations upon the bones. The important point brought out was that lateral deformities of the foot must be corrected or prevented permanently in order to have maximum function and freedom from pain. The lateral deformities referred to are inversion or eversion ones and are far more disabling and difficult to treat than those of calcaneus or equinus. If the leg is completely paralyzed or flail, almost any type of support will be sufficient to prevent the occurrence of deformity, but, if any of the invertor or evertor muscles, namely tibialis anterior and posterior, or peroneus longus and brevis are present, it is almost impossible to prevent varus or valgus deformities of the foot. Braces of Hessing and caliper types have been tried, but in spite of these the feet roll into inversion or eversion and painful callosities develop over prominent bony points due to friction on pressure of the braces. The only means of successfully combating this deforming tendency is operative fixation of the foot in the subtalar articulations accompanied where possible by the transplantation of the good muscles to positions of more useful function. As has been mentioned before, stability upon weight bearing is of prime importance, and the conviction that this stability can be ensured permanently only by bony fixation is becoming more firmly implanted every

day. The necessity for adopting the Basle anatomical nomenclature terminology in anatomical references has not been recognized to any extent in recent literature, although in most medical schools this is the only terminology taught. From personal experience one has realized the difficulty of trying to keep straight in his mind the different terms used to describe the same bone. The writer hopes to be pardoned for adhering strictly to the new terminology even at the expense of referring to certain well known operations by apparently new and unfamiliar names.

All operations designed to prevent lateral deformity of the foot are directed at the subtalar (subastragaloid) joints. Royal Whitman, in 1901, described his talectomy (astragalectomy) with posterior dislocation of the foot as a method for producing lateral stability while still retaining useful flexion and extension in the ankle. It was a great surprise to the writer on examining some of the end-results of this operation to find such satisfactory stability combined with a free range of flexion and extension when the operation in itself did not seem to be a good one from the standpoint of anatomical construction. Realizing that talectomy may not find favor with all surgeons, the results obtained in certain cases label it as a highly satisfactory procedure. The peroneal tendons when active may be transferred to the tendo achillis to increase the power of plantar flexion.

Arthrodesis of subtalar joints by resection of the joint surfaces is more uniformly satisfactory in many hands. Dr. G. G. Davis is probably to be given credit for the principle of fusion of subtalar joints to produce lateral stability of the foot, although the description of the Hoke operation in 1921 has a more scientific foundation. Fundamentally, all operations of this type obtain fusion between the talus, navicular (scaphoid), and calcaneus by resection or destruction of the articulating surfaces and are developed essentially upon the principles of the original Davis procedure.

Ryerson, reporting his observations on a large number of cases which had been subjected to arthrodesing operations, stated that his most successful tendon transplantation occurred in these cases. His description, in 1923, of a triple or three joint arthrodesis gave us another modification of the original principles. The three joint arthrodesis probably has the widest acceptance among orthopedists today. All cases about to be reported in this paper are those in which this type of arthrodesis, consisting in fusion between talus, navicular, calcaneus, and cuboid bones, has been performed. The results obtained in the writer's hands have been most satisfactory.

Getting back to the question of transplanting of tendons, it has been stated that lateral muscles, if not paralyzed, must be transplanted into the Achilles tendon or to the front of the foot. There are two chief reasons why this should be done. First, a deforming force is removed from an undesirable position to one of correction and improved function. Second, flexion and extension of the ankle joint may be obtained or improved by transplanting lateral muscles to the anterior or posterior part of the foot as indicated.

TECHNIQUE

The technique followed has been practically standardized. The approach to the subtalar joints is through a curved incision on the lateral side of the foot extending from the head of the talus backward and downward to a point one-half inch below and anterior to the tip of the lateral malleolus. If the peroneal tendons are to be transplanted to the front of the foot or to the Achilles tendon the incision is extended around the lower and posterior margin of the lateral malleolus and proximally up the leg along the course of the peroneal tendons for a distance of about 6 inches. After the fat, interosseous talocalcaneal ligament, and periosteum are removed from the sinus tarsi and the bony surfaces bounding it, an excellent exposure of the subtalar and calcaneocuboid joints is obtained. The apposing surfaces of the anterior, middle, and posterior talocalcaneal joints are excised in the horizontal plane. The head, with a generous portion of the neck of the talus, is removed and the corresponding articulating surface on the navicular bone is excised in the coronal or frontal plane. The calcaneocuboid articulation is likewise excised in the same plane. The excision of joint surfaces and the neck of the talus allows of the foot to be dislocated well posteriorly upon the talus conforming to the requirements of good stability as suggested by Hoke. Valgus or varus deformities of the foot can be corrected by varying the plane in which the various subtalar joints are excised. Two or three interrupted plain No. 0 catgut sutures are inserted to hold the foot in posterior dislocation. At this point, one transplants the lateral muscles to the front or back of the foot as conditions indicate.

Only four groups of muscles will be considered in the foot at this time, in an attempt to make the problem as simple as possible.

When the tibialis anterior is the only active muscle in the foot, the deformity is one of calcaneo varus. If accompanied by tibialis posterior and calf muscles, equinovarus is the usual position. If

the peroneals act with the anterior tibial in the absence of calf muscle power, a calcaneus deformity results. The peroneals alone or with the calf muscles produce valgus deformities. The calf muscles alone or with invertors or evertors produce equinus positions. The posterior tibial alone or with the peroneals in absence of the anterior tibial and calf muscles produces a cavus or hollow foot with a complicating calcaneus deformity. It would be possible to refer to many other variations in the four basic positions of deformity produced by different groupings of the muscles mentioned, but it is not necessary to consume more time for this. The question of which muscle is to be transplanted with the subtalar arthrodesis has been decided before operation.

The technique followed does not vary to any extent from that of Lange and others in which the tendon is passed through a tunnel in the subcutaneous tissue to be fastened to the bone in the forefoot or to the tendo achillis in the posterior foot. The tendon to be transplanted is divided as far distally as possible and a figure-of-eight chromic catgut suture is placed through the distal end. A space is tunneled through the subcutaneous tissue from the proposed point of insertion to well up on the leg so as to be sure that there will not be any angulation in the course of the tendon from muscle belly to insertion.

In the case of transference to the front of the foot, a tunnel large enough to allow the passage of the tendon is bored through the middle cuneiform to the sole of the foot, as suggested in the transosseous method described by Mueller. Next, the sheath of the tendon to be transplanted is opened and the tendon is removed with as much of the paratenon and mesotenon as possible and immediately drawn carefully through the subcutaneous tunnel to the dorsum of the foot. All tunnels for the passage of tendon have been constructed previous to opening the tendon sheath so that the delicate paratendinous structures will not be exposed to drying by the air. The writer tries to pass the tendon under the transverse ligament on the dorsum of the ankle and foot. Failing to do this, although the function is not impaired, the transplanted tendon stands out like a bowstring when its muscle contracts.

The catgut suture previously placed in the distal end of the tendon is threaded through a long straight needle which is passed through the tunnel in the middle cuneiform and through the sole of the foot drawing the tendon after it down as far as the plantar fascia. A one-half inch incision is made in the sole of the foot so that the chromic catgut may be tied, thus fastening the transplanted tendon to the plantar fascia. It is important, however, that the degree of tension upon this tendon is sufficient to keep it taut before it is tied. It is very difficult to decide upon how much tension is necessary, but with experience one learns of the happy medium between too tight and too loose. The tendon must also be fastened to the periosteum surrounding the dorsal end of the osseous tunnel. The fixation obtained is highly satisfactory and it undoubtedly warrants this detailed description. The method is not, of course, original, having been observed in the work of Sir Robert Jones, and is a very valuable one.

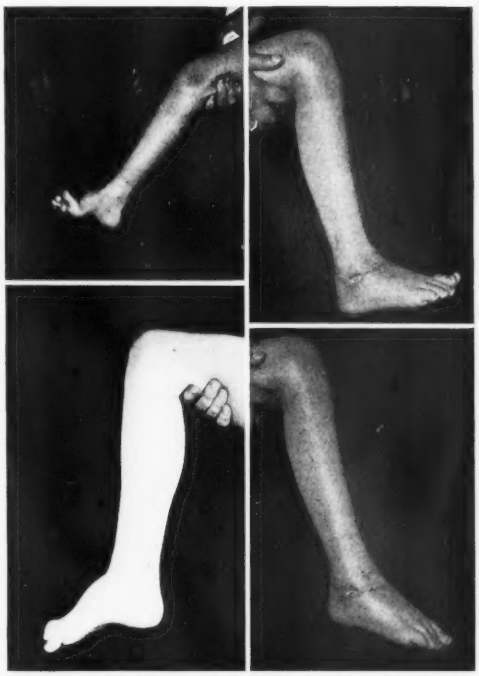

Fig. 1. Case 1. A. N., No. 203. Four views of the right foot are shown. Variations in photographic technique account for the positions used and variation in intensity of the pictures. The upper two views show the active dorsiflexion of the foot before and after subtalar arthrodesis and transplantation of the insertion of the tibialis anterior tendon from the medial side of the foot to the region of the middle cuneiform. The lower views show the active plantarflexion before and after operation. Photographs are not available showing the correction of lateral deformity and the stable position of the foot on weight bearing. The scar from the arthrodesis shows the delayed healing so often found before the technique used in closing the wound was changed as mentioned above.

When the peroneal tendons are to be transplanted into the tendo achillis, the preliminary

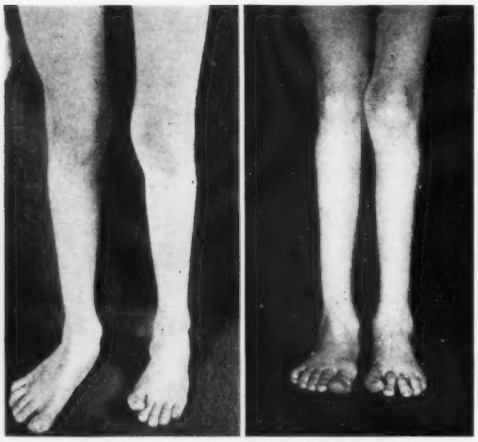

Fig. 2. Case 2. No. 214. Two views of the weight bearing position of the feet before and after operation are shown. The marked everted or valgus position of the right foot is to be noted. The left foot is in a moderately severe varus position. In the right view the excellent weight bearing position is apparent.

Fig. 3. Case 2. No. 214. The amount of active dorsiflexion and plantarflexion obtained after a stabilization of a paralytic talipes with transference of the peroneal tendons to the front of the foot is shown. Plantarflexion of 45 degrees is shown above while the 90 degrees of dorsiflexion is shown below. A ridge caused by the tendon of the contracting muscle can be seen on the dorsum of the ankle. Dorsiflexion, in this case, is assisted by the pull of the toe extensors.

preparation to ensure lack of angulation is observed before freeing the tendon as described. The method of fixing these tendons into the tendo achillis has been suggested by an operation described by Royle for inserting the posterior tibial tendon into this structure in certain cases of claw foot. With a large eyed needle, the peroneus longus and brevis are laced back and forth through the tendo achillis and each other so as to lock the one into the other. One or two chromic catgut sutures are placed in these interlocked tendons and, after placing a few No. 0 plain catgut sutures in the subcutaneous tissue, the skin incisions are closed with an absorbable formalized catgut suture.

Attention must be called to a detail in the closure which is proving valuable in more recent cases. Incisions about the ankle in operations performed under tourniquet were found to be very much macerated and to have necrotic skin edges when the first dressing was done 2 weeks after operation. The probable cause for this was the tension of the wound produced by the œdema and hæmorrhage following release of the tourniquet when the wound was closed tightly. Following observations made by others, the results obtained by closing the wounds with very few interrupted sutures so that marked tension would not occur in the wound have been very encouraging. There is rather marked staining of the plaster by the escaping blood but the wounds are usually healed when dressed in 2 weeks' time.

CASE REPORTS

A few cases are to be reported briefly. Good results are classified according to the rules laid down by Steindler of (a) stability on weight bearing, (b) permanent prevention of lateral deformities, and (c) more or less active function of the transplanted tendon in its new line of action.

Case 1. A. N., No. 203, female, aged 9 years. Acute poliomyelitis developed at the age of 8 years, involving both lower extremities and was treated by massage and corrective shoes. The patient reports to the hospital for further treatment because of the difficulty in walking.

Examination in respect to the feet shows a residual paralysis involving the left lower extremity. As the patient walks the left foot rolls into a position of varus due to the lack of power in her peroneal muscles. Figure 1 shows, on the left, the position assumed by the foot as the patient actively dorsiflexed and plantarflexed the foot. The prominence of the heel is due to the lack of power in the calf muscle as compared to the pull of the anterior and posterior tibialis muscles. As a result of the imbalance a varus and cavus deformity of the foot has developed. The instability is marked and callosities have developed on the outer side of the foot due to the position assumed.

On July 19, 1930, a subtalar arthrodesis with transference of the tibialis anterior from the inner side to the middle of the front of the foot was done, the technique described being used. The posterior dislocation of the foot with the change in direction of the pull of the tibialis anterior muscle has resulted in a much better balanced foot. On the right in Figure 1, the result following operation can be seen. Per-

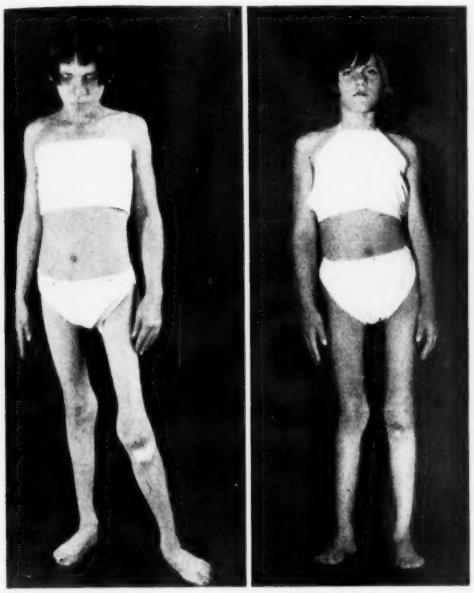

Fig. 4. Case 3. E. S., No. 211. The view on the left shows the condition on admission. The bilateral talipes valgus is apparent and that on the left side is complicated by a contracture of the tendo achillis which the patient compensates for by advancing the foot slightly. All the weight is borne on the right extremity because of the paralysis of the left quadriceps femoris. The right view shows the condition on discharge. The valgus deformities have been overcome permanently and both feet are in position for good weight bearing as the patient demonstrates.

fect stability is present although not shown in this view. A permanent prevention of lateral deformity is assured and plantar flexion of 50 degrees with dorsiflexion of 90 degrees is possible. The transplanted tendon can be seen as a prominent ridge on the dorsum of the foot and ankle. The result is classified as good.

Case 2. M., No. 214, female, aged 8 years. Anterior poliomyelitis involving both lower extremities developed in 1924 at the age of 2½ years, and the patient was admitted 6 months later to the out-patient department of the hospital, where her parents were instructed in physiotherapy including muscle training. A brace was applied to the left leg, but at the time of admission to the hospital for operative treatment the brace had not been worn for about 2 years. The right leg showed good power in the calf muscles, a trace of power in the invertors and good power in the peroneals, and, as a result, a very unstable foot in marked valgus was produced. On August 17, 1929, a subtalar arthrodesis with transference of the peroneal tendons from the outer side of the foot to be inserted into the medial cuneiform as previously described, was performed. Figure 2 shows on the left the right foot in marked valgus and, on the right, the good weight bearing lines obtained by the operation. Figure 3 demonstrates clearly the plantar flexion to 45 degrees and the dorsiflexion to 90 degrees which remained. It is regretted that photographs showing these positions before operation were not obtained.

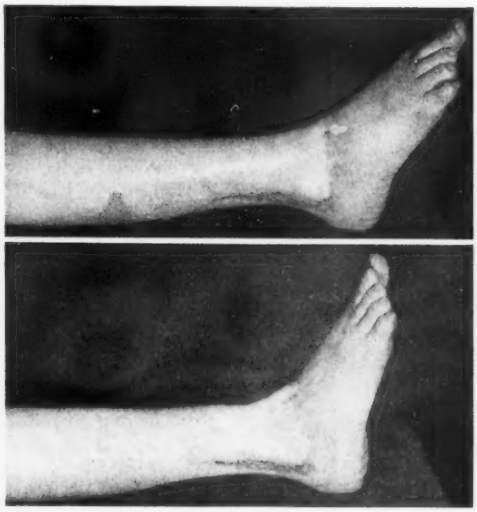

Fig. 5. Case 3. E. S., No. 211. The range of motion obtained by transplantation of the tendons of the peroneal muscles across the front of the right foot is clearly shown. This photograph was taken at an angle so that the true range of motion is not shown. Attention is called to the course of the transplanted tendon across the dorsum of the leg and foot as is shown in the lower view.

The excellent stability, freedom from lateral deformity, and useful range of motion label this as a good result.

A varus deformity of the left foot may be noted in Figure 2 also but, as this was treated by a different surgical procedure, no mention of it is made at this time.

Fig. 6. Case 3. E. S., No. 211. The upper view shows the range of active plantarflexion while the lower view shows the dorsiflexion. The contraction of the extensor tendons of the toes assists in the dorsiflexion of this foot.

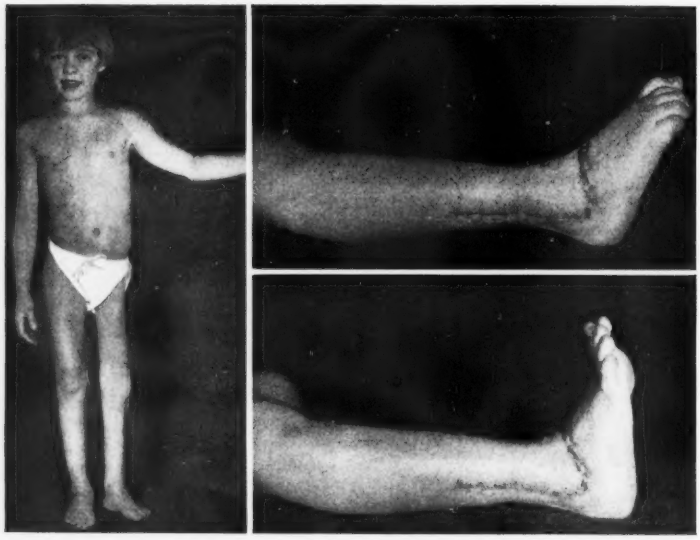

Fig. 7. Case 4. V. K., No. 200. The postoperative result obtained from subtalar arthrodesis with transplantation of the peroneal tendons to the front of the right foot is clearly shown in this view. On the left the weight bearing stability and freedom from lateral deformity in the right foot can be observed. On the right hand side, active plantarflexion and dorsiflexion are shown in the upper and lower views respectively. The course of the transplanted peroneal tendon can be made out in the lower view. The left foot has also been stabilized by an arthrodesis and bone block (Campbell).

Case 3. E. S., No. 211, female, aged 12 years. In September, 1921, when patient was 6 years of age anterior poliomyelitis developed and involved both lower extremities. She was in bed for 4 months. No specific treatment was given until 1924 when she reported at the hospital with a bilateral talipes equinovalgus deformity. Conservative treatment along the line of plaster-of-Paris dressings to stretch the tendo achillis and physiotherapy were given. Later she was supplied with braces and discharged.

In 1929, she was again admitted to the hospital as her braces were worn out. She was free from fixed deformities at this time. The power in her calf and peroneal muscles on the left side was evaluated as "good and normal," whereas there was no power in the anterior and posterior tibialis muscles. On the right side, the power in the calf was "good" as was that in the peroneal group. The anterior and posterior tibialis groups were totally paralyzed. On November 18, 1929, a three joint subtalar arthrodesis was done on the right foot following the usual technique and on November 30, 1929, a similar operation was performed upon the left foot.

On April 17, 1930, she was discharged wearing braces of the Hessing type on both legs to protect the transplanted muscles. Figure 4 shows the attitude assumed by the patient as she stood before and after operation. The severity of the valgus deformities of the feet cannot be appreciated in the photographs but the good weight bearing lines following operation are apparent.

Figures 5 and 6 show the degree of active plantarflexion and dorsiflexion in the right and left foot, respectively. As a matter of interest, it might be mentioned that this patient also had a transplantation of the biceps femoris to the patella on the left side with excellent results.

The good weight bearing stability plus freedom from lateral deformities and a good range of active motion produced by the transplanted tendons puts this in the satisfactory class.

Case 4. V. K., No. 200, female, aged 10 years. Anterior poliomyelitis developed at age 2 years, involving both lower extremities. Nearby doctors advised the parents that there was nothing to do for the condition and as a result the patient did not have treatment until 1 year after the onset. Satisfactory treatment could not be given because of the distance from the patient's home to the hospital. Two years after the onset she was admitted to the Gillette Hospital with deformities of both feet. The right foot exhibited a moderate degree of equinovalgus deformity due to the loss of power in the anterior tibialis muscle. After a period of physiotherapy following the correction of her deformities she was discharged wearing long braces on her legs. The equinovalgus deformity of the right foot became worse with passage of time and on July 12, 1930, a subtalar arthrodesis with transference of the peroneal tendons to the region of the middle cuneiform was done using the usual technique.

Unfortunately, photographs were not taken before operation but Figure 7 shows the postoperative result. The excellent stability, the lack of lateral deformity, and the plantar flexion of 40 degrees with dorsiflexion of 95 degrees make it possible to classify this as a good result. The prominence produced by the transplanted tendon as its muscle contracts is apparent on the dorsum of the ankle joint and foot.

Case 5. I. K., No. 115, female, aged 7 years. Anterior poliomyelitis developed in 1926 when patient was 3 years of age, and involved the left lower extremity. She was

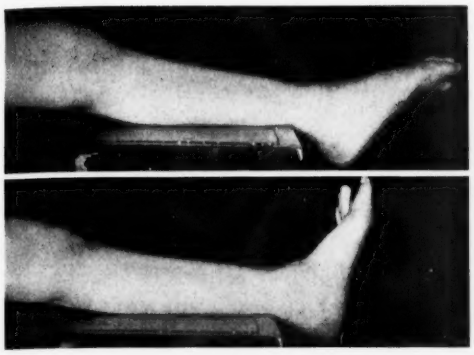

Fig. 8. Case 5. I. K., No. 115. The degree of active plantar- and dorsiflexion which is possible in the left ankle following subtalar arthrodesis and transplantation of the peroneal tendons to the front of the foot is shown. The toe extensors are apparently assisting in the action of dorsiflexion. Stability and freedom from lateral deformity have also been obtained although no photographs have been obtained to show this.

Fig. 9. Case 6. A. J., No. 169. A photograph taken from the medial side of the leg and foot shows the degree of active plantarflexion and dorsiflexion in the upper and lower views respectively. The ridge caused by the contracting transplanted tendon as it crosses the dorsum of the ankle and foot can be seen in the lower view. The apparent prominence of the heel is in part due to the posterior displacement of the foot as recommended by Whitman, Hoke, and others, in their descriptions of stabilizing operations upon the feet.

able to walk with difficulty, dragging the left leg with the foot in marked valgus. One year later she was fitted with a brace and advised to wait a few years before any further treatment was undertaken. She was admitted to the hospital in May of 1930 for operative treatment. Examination on admission showed a marked valgus deformity of an unstable left foot. There was also a mild degree of contracture of the tendo achillis. The power in the calf muscles and peroneals was excellent whereas the anterior tibialis muscle was completely paralyzed. On May 4, 1930, a three joint subtalar arthrodesis with transference of the peroneal muscles to the region of the middle cuneiform was done using the usual technique.

The result obtained was very good as the stability was good, there was a permanent prevention of lateral deformities and the transplanted muscles allowed dorsiflexion to 90 degrees and plantarflexion to about 55 degrees. Figure 8 shows the degree of active plantarflexion and dorsiflexion resulting from the stabilization and transference of peroneal tendons. Unfortunately, photographs before operation are not available.

Case 6. A. J., No. 169, female, aged 8 years. In 1927, anterior poliomyelitis developed at the age of 5 years, involving the left lower extremity. She had improved definitely following her illness which lasted only about six weeks until reaching the present residual stage of paralysis. No expert treatment had been received.

Examination upon admission to the hospital in 1930, 3 years after the onset of the disease showed the patient able to walk but the left foot was very unstable upon weight bearing, assuming a position of equinovalgus. The power in the calf was rated as "fair," the peroneals "good," while the anterior and posterior tibialis showed a mere "trace."

On June 14, 1930, a three joint subtalar arthrodesis with transference of peroneal tendons to the region of the middle cuneiform was done. Following the operation perfect stability free from the occurrence of lateral deformity with dorsiflexion of 100 degrees and plantar flexion of 50 degrees was obtained. The result is a good one (Fig. 9).

Twelve additional operations performed upon 10 patients will not be reported as description would be merely repetition. Briefly, in 11 of these operations the stability and freedom from lateral deformity was good. The function of the transplanted tendons was good in 10. One failure was obtained but this was not a bad result because the arthrodesis gave good stability. The twelfth case was discharged and did not return.

Fig. 10. This and the succeeding view are offered as an example of the very satisfactory result obtained by transplantation of tendons with subtalar arthrodesis. In this figure the positions assumed by the foot in attempting dorsiflexion and plantarflexion are shown. The dropping of the heads of the metatarsals with cocking up of the toes on attempting dorsiflexion when the anterior tibial muscle is paralyzed is demonstrated in the lower view. Compare this with the result obtained following operation in the next figure.

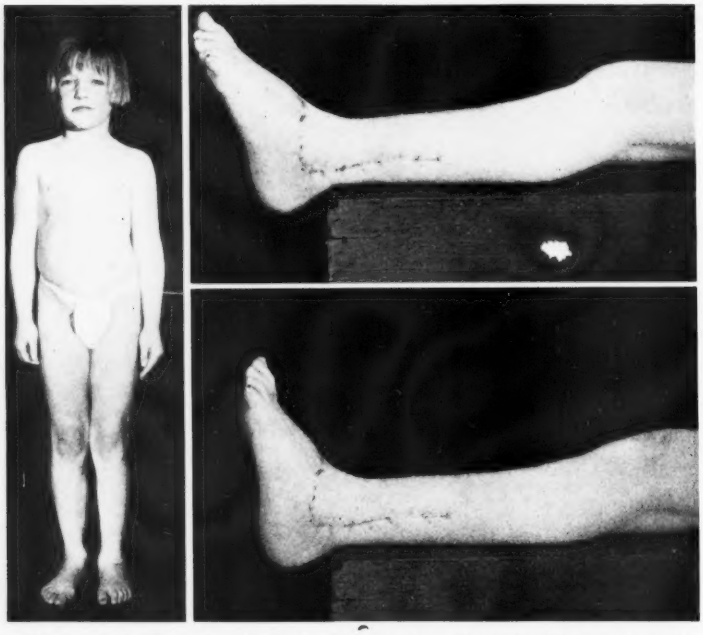

Fig. 11. A. C. The end-result obtained by subtalar arthrodesis with transplantation of the peroneal tendons to the middle of the front of the foot is shown above. The front view on the left shows what is considered to be excellent weight bearing position with the foot directly under the weight bearing axis of the leg with absence of lateral deformity in the foot itself. The views from the lateral side on the right hand show the degree of active plantarflexion and dorsiflexion which is possible.

CONCLUSIONS

Such a small series of cases as is here presented does not form an adequate background in itself for the formulation of an opinion as to the value of this operation. The experiences of others with this type of operation and personal observations upon three joint arthrodeses performed alone or combined with other procedures in the treatment of instability of the paralytic foot make it possible to testify regarding the value of the operation described.

The stability on weight bearing obtained by the three joint subtalar arthrodesis does not admit of any argument. The permanence of the correction of lateral deformity by arthrodesis depends upon the removal of deforming forces, such as the invertor or evertor muscles. The amount of motion obtained by utilizing the active lateral muscles depends to a great extent upon adherence to the rules outlined.

Arthrodesis of the subtalar joints should yield at least 90 per cent good results, the percentage being increased with added experience of the surgeon. The poor results or failures are almost without exception due to errors in judgment or operative technique.

SUMMARY

1. Final operative treatment in infantile paralysis should not be undertaken until the residual stage at least 2 years after the onset of the disease has been reached.

2. In untreated cases, deformities should be corrected and a period of conservative treatment by physiotherapy and mechanical fixation instituted before any operative treatment is undertaken.

3. Transplantation of tendons, although attractive from a theoretical standpoint, has not proved satisfactory in itself.

4. As stability of the feet with freedom from painful lateral deformities is the most desirable end-result, an operation designed to fuse joints through which the deformities occur should be performed.

5. Any lateral muscles having useful power

must be transplanted into the tendo achillis or front of the foot as indicated.

6. Children should be at least 6 years and preferably over 10 years of age before any bony operation is done.

7. A brief consideration of the rules governing the transplantation of tendons is offered.

8. Subtalar arthrodesis is described briefly.

9. A change in the nomenclature of operative procedures to that taught at present in the medical schools is suggested.

10. Six cases are briefly reported.

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OPERATION FOR DIRECT INGUINAL HERNIA[1]

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THE problems presented by "abnormal protrusion of a viscus through a normal or abnormal opening" have not occupied as much space in modern literature as existing facts seem to warrant.

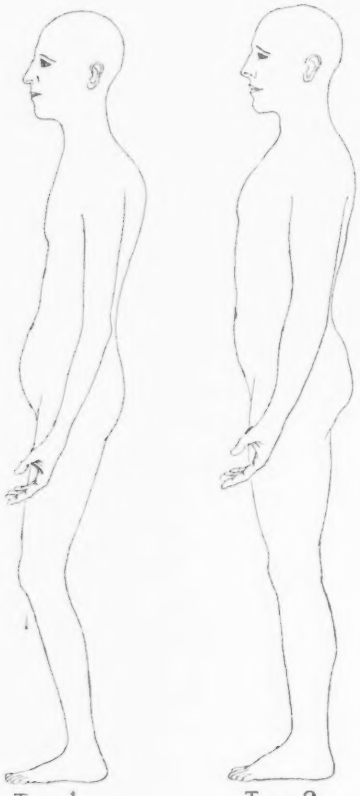
Traumatic surgery, if not the most active department of general surgery at present, certainly approaches that distinction. The spirit of the age is not only responsible for more accidents, but for more serious accidents. While the type of hernia which I wish to discuss in this paper may be influenced by predisposing factors, and is not entirely the result of a sudden, violent tearing, it must be admitted that in all probability repeated traumata play a part in dislocating the various structures producing an abnormal opening and abnormal protrusion.

The two types of inguinal hernia provide the greatest number of hernia problems. The multiplicity of methods of treatment seems to be a confession of failure and offers for argument one or two premises. Either the existing pathological change has not been appreciated, or faulty principles have been utilized in correcting the deformity. Confusion in the treatment of the two types is the result.

In the hope of clarifying these problems and for the purpose of formulating a method of cure, especially for direct inguinal hernia, a general study of those afflicted with inguinal hernia was made.

Briefly these patients may be placed in two groups. Type one represents the group with which this paper is chiefly concerned. The profile was made by me using the subject observed by the artist before the operation. The accompanying drawings were made from the same subject, during the operation. In this group, as a rule, with exceptions, the man is a blonde, or light brunette; the body is more or less hairless, the non-resistant type; the skin sort of hangs; the head and neck seem to be supported too far forward; the chest is flat; the back is humped in the thoracic region; the epigastrium is flat; the hypogastrium is relatively prominent; instead of the curvature being in the lower back to compensate for the thoracic deformity, it is flat; the musculature is obviously weak, especially in the lower abdomen where marked bulging may be seen over the inguinal regions, especially when patient coughs or when he lies on his back as he elevates his head from the pillow; the patient is typically visceroptotic; the thighs are flexed on the body and the knees are flexed; the distances between the ischii and the tip of the coccyx are appreciably lengthened; the gluteal muscles instead of giving a tight, compact arrangement about the anus permit a looseness which is also noticed when the sphincter is examined digitally. From a careful examination of type one it is very apparent that when hernia exists, one is dealing with a weak link in a weak chain.

Type two, represents just the opposite of type one. If this type be the victim of hernia, it will probably be because there is a weak link in a strong chain.



Type 1. Type 2.

[1]Read before the Baltimore City Medical Society.

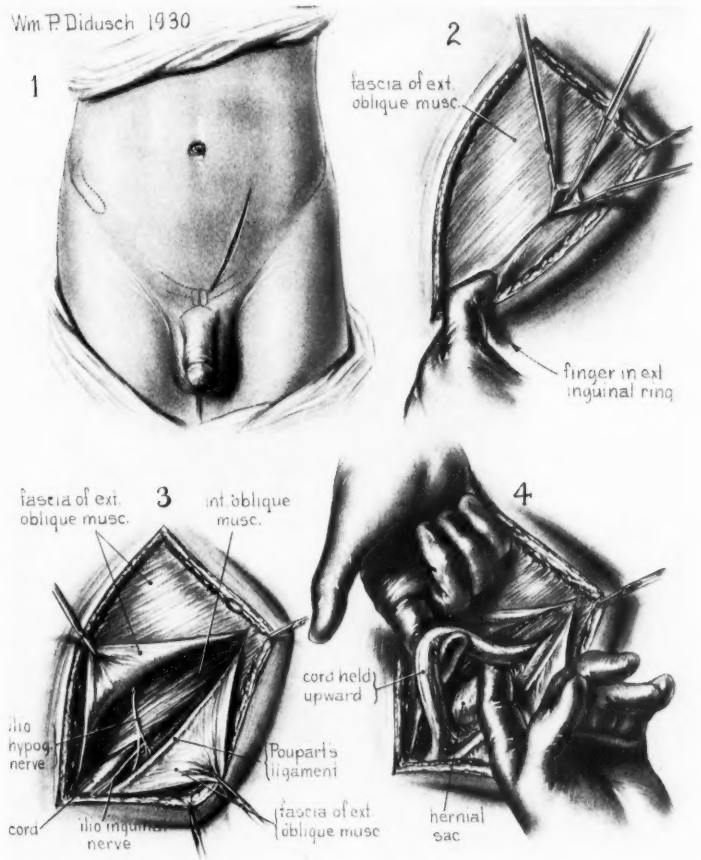


Fig. 1. *1*, Location of incision; *2*, point selected in separating the fibers in order to protect the nerves; *3*, dissection of the external oblique, both nerves and cord exposed; *4*, cord lifted out of the inguinal canal with a gloved finger, cremasteric being separated from its attachment to the internal oblique. Hernia sac protruding through Hesselbach's triangle.

The treatment of type two offers little difficulty. Most cases are detected in childhood, and are cured if the sac is removed properly and the cord is allowed to fall back into its original position.

Taylor,[1] in a review of the Hopkins Hospital records, showed failure to cure in over 18.8 per cent of patients operated upon in this, the direct inguinal group. Before Taylor's report was published, my own failures in direct hernia operations by the Bassini method, occasionally reinforcing with the rectus sheath, convinced me that it was not altogether my fault. As a result of dissatisfaction, I evolved a method, the principles of which, so far as I know, hitherto have not been utilized.

Before I describe the operation it would seem worth while to mention the need of prevention in connection with hernia. It is becoming increasingly difficult, as the result of laws of compensation in various states, for men below par physically to secure employment. In some of the states even though a hernia develops while the patient is in the discharge of duty, unless there is a definite history of accident, it becomes a personal responsibility.

Group one offers the greatest number of problems in this respect. Along with other pre-

[1] Taylor, A. S. Arch. Surg., 1920, i, 382-406.

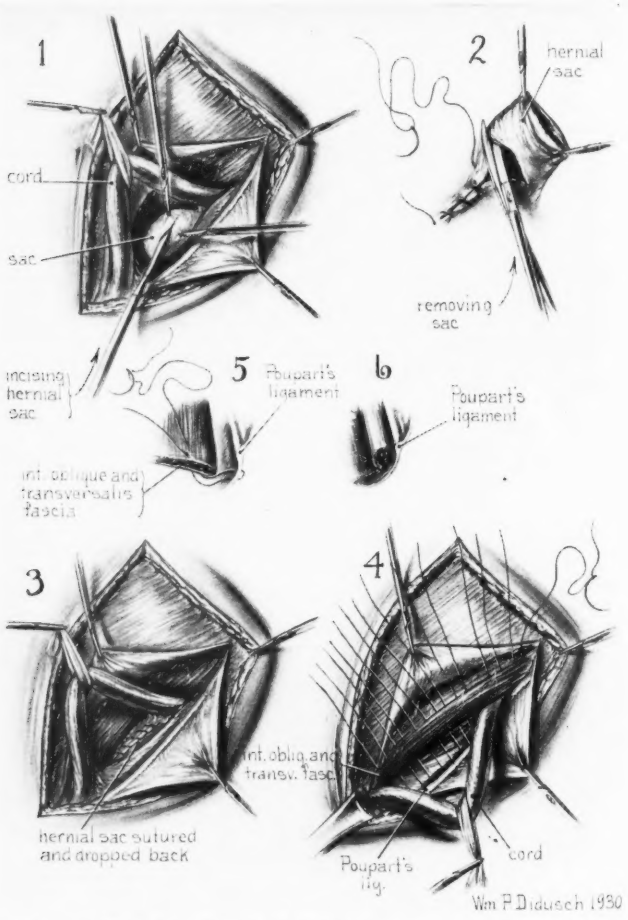


Fig. 2. *1*, The sac is exposed and incised; *2*, sac being sutured as divided; *3*, stump of sac closed; *4*, sutures in the internal oblique and Poupart's; *5*, internal oblique and transversalis fascia prepared for suturing; *6*, internal oblique and transversalis fascia attached under the shelving of Poupart's ligament.

ventative measures, it would seem wise that those potentially afflicted with hernia of the direct type should be fitted to their jobs and not be subjected to the physical violence that so often results in the formation of hernia. This could easily be done by examination before employment, and group one selected for light work and group two for heavier jobs.

OPERATION

Incision is made through the skin as far over toward the median line as subsequent dissection of anatomical structures permit (Fig. 1, *1*). It is near the outer border of the sheath of the rectus abdominus muscle. The external oblique is then cleared of loose tissue, care being used to guard the ilio-inguinal and ilio-hypogastric nerves. To accomplish this, the fibers of the external oblique (Fig. 1, *2*), are separated at the weakened point which begins above the usual location of the nerves. The cord is then exposed by gentle dissection, with the gloved finger (Fig. 1, *3*), the two flaps of external oblique aponeurosis are dissected back, thus exposing Poupart's liga-

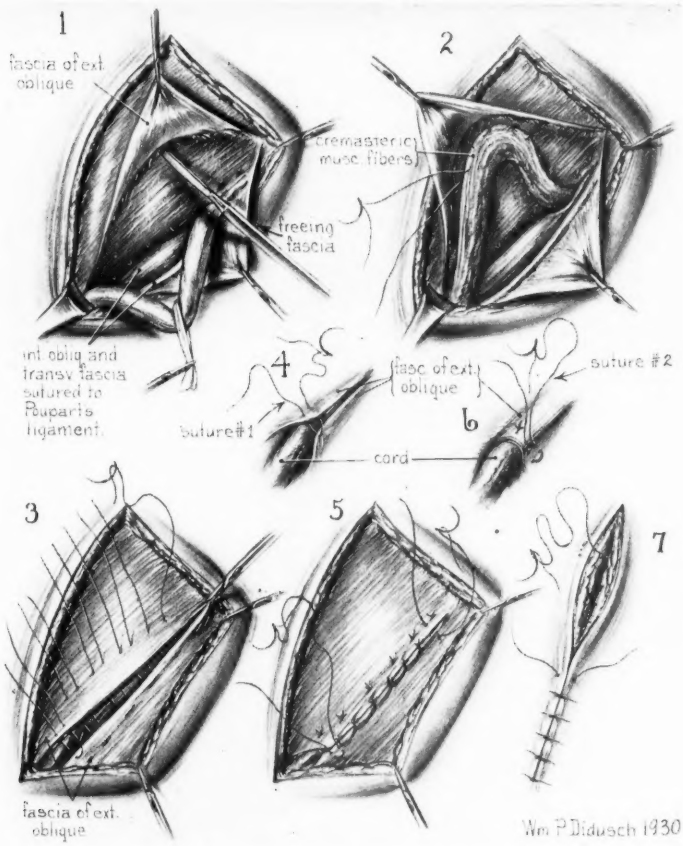


Fig. 3. *1*, Internal oblique completely closed with a roll of muscle bundles so arranged that the knots of the sutures will be practically covered, the external oblique being freed more completely, exposing the semilunar line; *2*, the cord being gracefully curved toward the midline, the cremasteric fibers being sutured to the internal oblique, following the direction of the semilunar line; *3* and *4*, the lower flap of external oblique being drawn under the upper flap, with an extra suture overlapping the anterior segment of the ring; *5*, upper flap overlapping lower flap; *6*, the final suture in the external ring applied; *7*, No. ◻ catgut closing the deep fascia, silkworm gut closing the skin.

ment on one side and the external surface of the internal oblique to the linea semilunaris on the other. The cord is then dissected up with the gloved finger (Fig. 1, *4*), beginning at the external ring and gently lifting it out of the canal, liberating fibrous bands, and carefully guarding against damage to the blood vessels. The cremasteric muscle is then freed from its origin, to the extent necessary to gain sufficient mobility and length to permit the cord to function in the new field to which it will be transplanted. If the cord is unduly massive, as a result of properitoneal fat or dilated veins, or as was found in a recent case, an old, quiescent, indirect sac, it is reduced in size by appropriate removal of the offending tissues. The sac, which at this stage can easily be seen protruding through Hesselbach's triangle, is then opened (Fig. *2*, *1*). In this type of hernia, the sac is almost sausage shaped presenting transversely instead of end first. For this reason, it is unwise to attempt to transfix, amputate, and transplant the stump, as

suggested by Kocher, in an indirect hernia. On the left side, the sigmoid, and on the right side, the cæcum, and even the urinary bladder, may be injured; therefore, the sac is opened, sutured, and divided in full view (Fig. 2, *2*). The stump is closed and dropped back (Fig. 2, *3*). The internal oblique and transversalis fascia are then sutured to the base of Poupart's ligament (Fig. 2, *4*), as far back toward the abdomen as possible (Fig. 2, *5*), an attempt being made to make this part of the abdominal wall lean inward instead of outward. The row of knots of chromic catgut is so placed that the muscle bundles of the internal oblique practically hide them (Fig. 2, *6*) and prevent their contact with the next layer, the aponeurosis of external oblique. It will also be noted that the sutures are so placed that they do not strangulate the muscle bundles (Fig. 3, *1*).

The cremaster muscle is then sutured in a manner that will cause the cord to be spread out in a fan-like arrangement (Fig. 3, *2*) from the point at which it emerges, through the internal ring, curved across and fastened to the outer surface of the internal oblique until it reaches the semilunar line, thence along that line to the external ring. The cremaster in its new position not only flattens the cord and produces a valve-like slit of the internal ring, but also removes the weakening influence of the cord from the inguinal canal, thus permitting the internal and external oblique to act as adjuvants to each other and in addition suspending the testicle, thus diminishing the chances of venous embarrassment. The external oblique (Fig. 3, *3*) is then sutured in a way that permits an overlapping of the anterior (Fig. 3, *4*) and weak segment of the external ring. (Fig. 3, *5* and *6*) show the final arrangement of the external ring. After the subcutaneous fascia is closed with fine catgut the skin is closed with interrupted silk worm gut (Fig. 3, *2*).

If there has been a recurrence following this method, I do not know of it.

EDITORIALS

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JUNE, 1932

THE PROBLEM OF THE STIFF JOINT

KNOWLEDGE can be acquired by many but wisdom is more elusive and its acquisition is limited to a few. Occasionally, from a wealth not only of sound knowledge, but also of large and varied experience, some one pours forth in his teaching wisdom that is so fundamental and simple that all who hear must heed. Sir Robert Jones, in his William Mitchell Banks Lecture[1] in Liverpool, 1931, demonstrated such wisdom.

The lecture covers a large subject in a comprehensive manner, takes up in orderly fashion and deals squarely with such problems as joint adhesions, the question of rest or movement, the prevention of stiffness, stiffness following fractures in and about joints, treatment of stiffness due to arthritis, prolonged immobilization of a fractured limb, active and passive movements, myositis ossificans traumatica and ischæmic palsy. Sir Robert gives his own technique of forcible manipulation for treatment of the various joints such as those of the knee, shoulder, and elbow, and his treatment of acute suppurative synovitis, rheumatoid disorders, and fixed ankylosis. Such a group of conditions is not considered in textbooks, so the article is invaluable. The subject matter is most clearly presented in Sir Robert's inimitable style.

Sir Robert called attention to the fact that in England the "irregulars," the "bone setters," are too often attempting to relieve conditions that should be cared for by members of the medical profession. It is futile, he said, for the medical profession to cite the numerous failures and the injured joints for which bone setters may have been responsible. It is far better to inquire into their successes and the cause of them concerning the care of stiff joints. "The ordinary textbook," he declared, "if it deals with the question at all, does so in an indefinite way, and invariably leaves us without practical guidance; as a sequel to this we have unqualified practitioners all over the country who render stiff joints mobile with a success sometimes very disconcerting."

The lecturer emphasized that a stiff joint is generally due to the presence of adhesions, within or around the joint; often adhesions are present in both places. An adhesion is at first merely a pathologic band, restricting movement between adjacent tissues; it arises from a serous or hæmorrhagic exudate, either inflammatory or traumatic. This band becomes fibrous, loses vascularity and elasticity, and becomes in reality a cicatrix. An inflamed joint kept at rest too long after inflammation has subsided permits of the formation of unnecessary cicatricial bands. A joint stiffened by simple adhesions, whether

[1] "The problem of the stiff joint." Brit. M. J., 1931, December 5.

intra-articular or extra-articular should be moved, whereas a joint stiffened by arthritis should be kept at rest until pain and inflammation have subsided. To quote again: "A joint whose movement is limited in all directions is or has been subject to arthritis, while a joint which is limited in certain directions only, movements being normal in others, is not arthritic."

In dealing with differential diagnosis, Sir Robert stated: "Definite localized pain is experienced when adhesions are put on strain, and the tenderness can generally be localized on pressure. It is more diffuse in arthritis. An adhesion is most painful when a joint is moved and less so when the joint surfaces are pressed together. In arthritis, pain is more pronounced when pressure is brought to bear on the bone surfaces. The temperature of the arthritic joint is usually increased over the whole articulation, while adhesions may produce localized surface temperature, but generally there is none. In arthritis the stiffness is progressive; in adhesions it is stationary or retrogressive."

In speaking of tuberculosis of joints of the adult, Sir Robert emphasized the seriousness of the problem, and although after prolonged conservative measures, with constant danger of dissemination, quiescence may be obtained, in reality ankylosis is required. For this reason, as soon as an accurate diagnosis is made of tuberculosis of the ankle, knee, or hip, he advises, except for children, an operation which will result in ankylosis.

The article should be read by all surgeons having anything to do with surgery of the extremities. It is of particular interest to the orthopedic surgeon, for in it he will find crystallized into definite observations his experiences. The larger his experiences the more enthusiastic will be his reception of such a lecture. MELVIN S. HENDERSON.

THE RECOGNITION AND TREATMENT OF SURGICAL SHOCK

THE work of Blalock and his associates and of Parsons and Phemister has served to stress the significance of blood loss in the production of shock. They have adequately shown that a satisfactory explanation for the depressed arterial pressure accompanying traumatic shock is to be found in the amount of blood lost into the injured tissues. The fall in blood pressure attending the release of a tourniquet upon a damaged extremity is due not to the absorption of a histamin-like substance from the injured tissues but to bleeding through the leaky vessels of the injured extremity.

The symptoms of shock are those of hæmorrhage. A hurried pulse and a depressed arterial blood pressure are the most significant signs. Rarely, shock obtains when the pulse rate is normal. The blood pressure is the most reliable guide in determining whether shock is present. A patient with a systolic blood pressure of 100 or less after severe injury is in potential shock. When the pressure is 90 or less the patient is in actual shock and energetic treatment should be instituted. At the critical level of blood pressure, 70 millimeters mercury, an inadequate blood flow is afforded the vital centers, which, if continued for a few hours, will terminate fatally despite energetic eleventh hour expedients.

An array of widely differing conditions better described as instances of syncope, collapse, or prostration are not infrequently erroneously labelled shock. In the dramatic catastrophe consequent upon perforation of a duodenal ulcer, this confusion is well illustrated. Severe prostration is uniformly present; shock almost never. The pulse may be slightly quickened, but the blood pressure is normal.

The rationale of treatment in shock consists of measures that replenish the depleted blood

volume. Adequate hæmostasis should be secured as quickly as possible. In operations of election, careful deliberate hæmostasis is the best prophylaxis against shock. Relief of pain, the application of external heat, and the free oral administration of warm fluids are symptomatic aids of great value. In the transportation of the injured, good immobilization of fractured bones is important in order to avoid or not to aggravate existing shock. Mild cases of shock respond favorably to intravenous administration of saline and the subcutaneous injection of ephedrin. There is no vasomotor exhaustion in traumatic shock; the value of vasospastic agents is limited to the treatment of mild shock and in determining whether other measures are necessary. In the fall of blood pressure accompanying spinal anæsthesia and that occurring after sudden removal of large quantities of fluid from the body cavities, the administration of vasospastic agents is urgently indicated, for in these conditions there is an actual lowering of the tone of the vessels. In these conditions too, the Trendelenburg posture has its greatest value. In traumatic shock, elevation of the foot of the bed and the Trendelenburg posture are of little value because little blood is mobilized from the constricted peripheral vessels by this maneuver and the blood is not in the venous reservoirs.

Glucose solutions are of no greater value than saline in the treatment of shock. There is no deficiency in the blood sugar and glucose in solution is a crystalloid and diffuses through semi-permeable membranes. Only a colloidal solution having the same osmotic pressure as blood will remain in the vessels. A 6 per cent aqueous solution of acacia which is now generally available exhibits this feature and is far superior to saline.

Even though patients in shock suffer more from depletion of the blood volume than from want of oxygen carriers, the most effectual means of restoring a diminished blood volume is transfusion of blood. In severe shock, preparation for transfusion should be made immediately, the temporary fortifying intravenous infusions of saline and acacia being given meanwhile. In the treatment of severe shock adequate replacement of the diminished blood volume is the significant factor. A single transfusion of 800 cubic centimeters of blood may be ineffective; when the blood loss has been great, several transfusions are in order. In shock, transfusion of unmodified blood by the Kimpton-Brown tube method has the advantage that a large transfusion can be given quickly with little cooling and with practically no trauma to the blood and consequently without reaction. At the University Hospital, over a seven year period, the blood grouping of convalescent cases that could well give blood (hernia, fracture cases, etc.) has been routinely determined after operation and satisfactory donors are always available. In those instances in which urgent necessity does not permit cross matching, group IV donors have been used with complete satisfaction. Many lives have been saved by this measure of preparedness. OWEN H. WANGENSTEEN

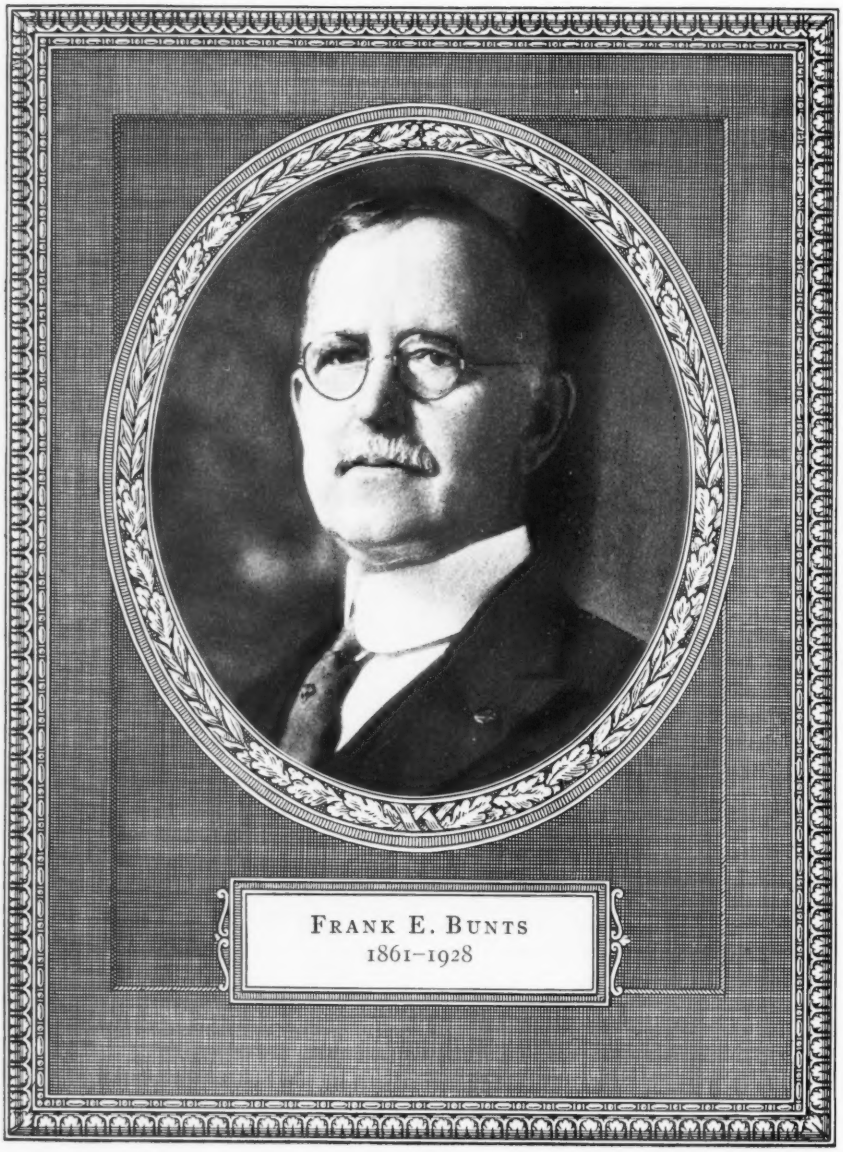
SIR HENRY WELLCOME HONORED

AT a recent meeting of the Council of the Royal College of Surgeons of England, The Right Hon. Lord Dawson of Penn, physician to His Majesty the King, and president of the Royal College of Physicians of London, and Sir Henry Wellcome, founder of The Wellcome Research Institution, were elected honorary fellows of the Royal College of Surgeons.

The bestowal of this signal honor upon Sir Henry Wellcome is a special one. Aside from members of the Royal Family, he is the second

person not holding a medical degree upon whom this rare distinction has been conferred. The first and only other recipient was Field Marshal Lord Roberts of Kandahar.

Sir Henry Wellcome is of American birth and known for his world wide scientific work, extensive researches in connection with tropical diseases. He founded the Wellcome Tropical Research Laboratories at Khartoum on the Upper Nile regions of the Sudan, Africa. He is also director of the Gorgas Memorial Institute, Washington, D. C., and its Tropical Research Laboratories at Panama.



FRANK E. BUNTS
1861–1928

MASTER SURGEONS OF AMERICA

FRANK EMORY BUNTS

ON November 26, 1928, Dr. Frank Emory Bunts, a master surgeon, died suddenly from heart disease. His death brought a deep sense of loss not only to his many friends and associates among the physicians of Cleveland, but also to physicians, friends, and former patients throughout the world, who have at some time come under the influence of his kindly and genial spirit.

Dr. Bunts was born in Youngstown, Ohio, in 1861, and received his education in the public schools. He then entered the United States Naval Academy at Annapolis, from which he was graduated with high rank in the class of 1881. All through his life and in all his relations he always bore the stamp of the navy.

After Dr. Bunts had served for two years with the Asiatic fleet, the opportunity was given the younger naval officers to resign, because the navy was overstaffed, and the young man decided to study medicine. After his graduation from the Medical School of Western Reserve University in 1886, he became house officer at St. Vincent's Charity Hospital, with which institution he was associated in various capacities for the rest of his life—42 years.

Twice Dr. Bunts interrupted his practice to study in foreign clinics. In the Spanish-American War, he served as surgeon to the First Regiment of Ohio Cavalry. He always retained his interest in military affairs and after the war, in the midst of a busy practice, he became captain of Troop A of the National Guard of the State of Ohio and served in this capacity for three years. At the time of the World War he again accepted a commission as Major, later becoming Lieutenant-Colonel, commanding General Hospital No. 9 at Rouen, France (Base Hospital No. 4, U. S. Army).

Dr. Bunts was the first president of the Cleveland Academy of Medicine and also served as president of the Cleveland Medical Library Association in 1927. He was a member of the American Surgical Association, the Ohio State Medical Society, the American Medical Association, the American College of Surgeons, the American Association for the Prevention of Cancer, the Société Internationale de Chirurgie, and the Société Française pour l'Avancement de Science.

From 1886 to 1893, Dr. Bunts lectured on surgery at Wooster Medical College, and from 1893 until the time of his death he was professor of principles of surgery and clinical surgery at the Western Reserve University School of Medicine. He

was visiting surgeon at various times to St. Alexis Hospital, St. Anne's Maternity Hospital, Mt. Sinai, and the Cleveland City Hospital; consulting surgeon to the Lutheran, Women's and Maternity Hospitals. He was one of the founders of the Cleveland Clinic Foundation and was chief of staff at St. Vincent's Charity Hospital, from 1913 until his death.

In 1888, Dr. Bunts married Miss Harriett E. Taylor. They had two children—Dr. Alexander Taylor Bunts and Clara Louise Bunts, wife of Edward C. Daoust.

It is difficult properly to evaluate this man. He possessed so many characteristics which make for greatness, combined with a retiring, unassuming personality. Perhaps one may safely state that the keynote of his character was his loyalty and constancy. His patients, his friends, the institutions he served all attest this fine quality.

Among Dr. Bunts' salient characteristics was his deep interest in civic and national affairs. He was a member of the Chamber of Commerce and served for years on its Committee on Military Affairs. He was a director of the Cleveland Trust Company. He was interested in, and furthered movements for civic improvement and was a frequent lecturer on patriotic subjects. He was a man of broad culture and wide reading. His numerous medical articles and the small volume of stories which he published some years ago have a characteristic individual charm. He was an enthusiastic fisherman and the month spent at Rose Point each year provided many anecdotes which were a constant delight to his friends.

An emphatic word should be added about his influence as a teacher upon the students with whom he came in contact in the medical school and in the wards of the hospital. Patience and understanding, with insistence upon accuracy in diagnosis and refined surgical technique in operating, were outstanding characteristics of Dr. Bunts, the teacher.

There are certain individuals who possess the rare quality of binding together those with whom they are associated, due to high intelligence, industry, uncompromising justice, fidelity, patience, a deep understanding of human frailties, and unfailing friendliness. Such a man was Dr. Bunts. GEORGE W. CRILE

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

AN excellent atlas[1] and text on the roentgenology of the urinary tract, bringing the reader abreast of progress in this field of roentgen-diagnostics, is that of Joseph and Perlmann. After the usual chapter on X-ray technique and apparatus, the authors proceed to a detailed description of the normal urinary tract, as seen in the roentgen films, with full reference to the influence of respiration, peristalsis in the ureters and renal pelves, and the emptying of the bladder. Stress is laid upon the advantage of small ureteral catheters over large ones. Urinary tract pathology is then considered at satisfactory length. Intravenous urography is described and discussed and the relative value of retrograde over intravenous pyelography carefully considered. Numerous instances are cited in which the intravenous method seems superior.

The illustrations constitute a splendid reference atlas, which, because of the explanatory notes in four languages (German, English, French, and Spanish), should appeal to a very large number of radiologists and urologists throughout the world. With rare exceptions the cases were verified at operation. The section on the bladder is exceptionally interesting. JAMES T. CASE

A DELIGHTFUL story of a Kentucky physician of the 70's and 80's.[2] The author writes of his father—sympathetically, yet without an obvious eulogistic tinge that would have destroyed the charm of the picture. Nevertheless, the reader senses the joy with which the son describes his father's admirable traits of character and his great success in practice. One reaches the last page with regret; he has been carried through a simple, sincere narrative that might have been prolonged with profit to at least double its length.

Robert B. Pusey lived with the ideals of his profession ever in the foreground; he served well. The hills and the valleys, the woods and streams were to him an unending source of delight, intimately interwoven with the tasks of the day.

In addition to its biographical features, the narrative is of value as it presents a clear picture of medical education and medical practice of the period. Numerous quotations from letters add a distinctly "source" character. Altogether it is a charmingly written narrative of a worthy man.

The publisher is to be congratulated upon an attractive format. IRVING S. CUTTER

THE popularity of Dr. McPheeters' book on varicose veins[3] is attested to by the publication of a third edition within 2 years. It is a most comprehensive survey of the entire subject of varicose veins of the lower extremity with special reference to the injection method of treatment.

The author reports some excellent experimental work done on the venous flow in varicose veins. By means of lipiodol injections into the varicosities and observation under the fluoroscope he shows that the blood current in large varicosities of the great saphenous vein of the thigh is stagnant or flows downward away from the saphenofemoral opening, the blood eventually emptying into the deep system of veins through the communicating branches. From this experiment and from clinical experience Dr. McPheeters believes that the rare incidence of pulmonary embolus following the injection treatment, but four cases reported in the literature, is due to the fact that an embolus formed in a peripheral varicosity will be arrested by the communicating branches which are smaller than the superficial varicose veins.

The advantages and disadvantages of the various sclerosing solutions are discussed at length. The solution used most frequently by the author is a combination of sodium chloride, invert sugar, and cane sugar with phenylcarbinol. As he attempts to thrombose all veins at one sitting with multiple injections large doses of this non-toxic solution may be given. He believes that quinine and urethane should be used for obliterating the occasional veins that are left, this solution being too toxic for large doses. This solution of quinine, however, has been used extensively and satisfactorily by other men who do not follow Dr. McPheeters' technique of multiple injections at one sitting and who believe that the patients are more comfortable if single injections of this solution are given over a period of

[1] FORTSCHRITTE AUF DEM GEBIETE DER ROENTGENSTRAHLEN. Edited by Dr. Grashey. Vol. xxxvii—DIE HARNORGANE IM ROENTGENBILD. By Prof. Dr. Eugen Joseph and Dr. S. Perlmann, Berlin. 2d rev. ed. Leipzig: Georg Thieme, 1931.

[2] A DOCTOR OF THE 1870's AND 80's. By William Allen Pusey. Springfield, Illinois: Charles C. Thomas, 1932.

[3] VARICOSE VEINS; WITH SPECIAL REFERENCE TO THE INJECTION TREATMENT By H. O. McPheeters, M.D., F.A.C.S. 3d ed. Philadelphia: F. A. Davis, 1931.

time. Both solutions will form sloughs if the technique is careless.

The author mentions the safety of using the sugar solutions during pregnancy in cases in which the quinine solution might induce abortion. He mentions, but does not emphasize, the advantages of sodium morrhuate with 5 per cent benzyl alcohol which solution is non-toxic, forms no slough, and yet is extremely efficient in the hands of the reviewer.

The illustrations in this book are good and there is a most extensive bibliography of the entire subject. For any man injecting varicose veins this work will be an excellent handbook. C. W.

THE book[1] on the pathology of the genito-urinary organs by Dr. Hertzler "presents the subject from the viewpoint of the general surgeon, freed as much as possible from the complications of the specialist." What these "complications" may be is not stated.

The material presented is quite complete and both photographs and photomicrographs are unusually well reproduced. The style of description makes reading easy and the personal opinions and individual experiences of the author are clearly stated in an interesting, and at times amusing, manner.

The subject matter is by no means limited to the pathology of the urinary organs but includes, under the heading of pathogenesis, etiology, prognosis, and treatment as these subjects appeal to the author. There are many sweeping statements in the treatise to which observers of equal or greater experience in this work might take exception.

However, the book is filled with wise observations on many important conditions and might be read with profit by one who would accept with some reservations the conclusions of an apparently experienced surgeon who has compiled his observations honestly and "freed from the complications of the specialist." VINCENT J. O'CONOR

THE wealth of diagnostic roentgenological information offered in the Schinz-Baensch-Friedl *Lehrbuch*[2] is amazing. Complimentary remarks are very much in order. Beautifully illustrated with a profusion of well reproduced roentgenograms, with adequate explanatory captions and numerous line drawings, this work commends itself at once to every German reading physician who attempts to employ the X-rays in his diagnostic work. Any oversights present in these volumes are completely submerged in the attractive features of this storehouse of knowledge. It should find its way to the desk of every roentgenologist who desires to keep up with the advances of modern X-ray diagnostics. Volume i concerns the skeleton; volume ii considers the respiratory, digestive, and genito-urinary systems. JAMES T. CASE

[1] HERTZLER'S MONOGRAPHS ON SURGICAL PATHOLOGY. SURGICAL PATHOLOGY OF THE GENITO-URINARY ORGANS. By Arthur E. Hertzler, M.D. Philadelphia: J. B. Lippincott Company, 1931.

[2] LEHRBUCH DER ROENTGENDIAGNOSTIK. By H. R. Schinz, W. Baensch, and E. Friedl. 3d ed. 2 vols. Leipzig: Georg Thieme, 1932.

A MOST elaborate monograph[3] on the use of electrosurgery has been written by Keysser and published in Germany. Keysser has divided the use of diathermy current for surgical purposes into electrotomy, or the use of cutting currents; coagulotomy, or cutting current with some coagulation, by which he describes a tissue effect similar to that introduced into our nomenclature as desiccation by Clark; electrocoagulation; carbonization; and fulguration.

He first describes the two apparatuses with which he experimented, one of which is manufactured by the Sanitas Company and the other one by the Siemens Company. Both of these machines are much more expensive than the American high frequency apparatus used in surgery, but the electrical currents used in the operations with these machines can be described quite accurately in electrical terms. Both the spark gap current and the current obtained by the radiotron have been investigated. He advises the use of the radio knife or current induced by the use of the radiotron only for cutting purposes, as, in his opinion, the radiotron large enough to induce coagulating current would be too expensive for commercial production. He lays some stress upon the wave length of the cutting current. A wave length of 300 meters is the average value in his cutting current. He finds the radio knife currents to be undamped and regards the undamped current as the best type for cutting. He finds that in all spark gap machines the air resistance damps the current, and that several types of wave are superimposed. With this machine he is able to arrive at only an average of the wave length of the various overlapping currents produced; this, for cutting purposes, averages about 300 meters. He believes that it is feasible to produce a machine with an oscillation as high as 100 million per second, and thinks such a current could be used to raise the body temperature without injury to the skin. It is notable that several such machines are being used for experimental purposes in America at the present time.

After a discussion of the tissue effects of the various currents, he gives a series of brilliant operative results, in which he was able to dissect large, superficial malignancies and immediately, or soon thereafter, close the gap with a skin flap. Many of these were cases in which the most intrepid operator would hesitate to approach with the ordinary scalpel method of incision. These illustrations demonstrate the feasibility of widespread dissection with cutting currents, leaving a wound which can be covered with graft without the delay of waiting while necrotic tissue sloughs away, as it does after electrocoagulation.

This is one of the most notable contributions to the theory and practice of electrosurgery that has been written.

JOHN S. COULTER

[3] DIE ELEKTROCHIRURGIE. By Prof. Dr. Franz Keysser. Leipzig: Fischer's Medizinische Buchhandlung, 1931.

AGAIN Dr. Graves has favored the profession with a timely contribution from his delightful pen. *Female Sex Hormonology*[1] is a review of the subject from its incipiency. Covering only one hundred pages, it presents concisely the 1931 status of female sex hormones in a clear, readable, and interesting manner. Although this review is primarily intended for students and classroom teaching, it has real value for the profession at large; many of us "do not have ready access to a literature . . . which is scattered in technical and foreign journals."

This book is introduced by a short chapter on the early history of female sex hormonology. This is followed by a discussion of sexual cycles in animals, sex cycles in the ovary, and sex cycles in the human uterus. Then Dr. Graves proceeds with the story of the search for hormones of the ovary, the discovery of the hypophysis as an agent in the sexual and reproductive cycles, and the problems involved in the separation of the various pituitary hormones. Three enlightening chapters are devoted to new theories of menstruation, parturition and lactation. He is fair and honest in the chapter on organotherapy, although it will undoubtedly prove disappointing to those men who are looking for a panacea in the treatment of endocrine disorders in women.

A glossary and an excellent bibliography conclude the book. This glossary gives one, at a glance, ready access to the new terms and ideas which recent investigations have introduced in the field of endocrinology as applied to women. The bibliography has been carefully selected and will serve as an invaluable addition to those who are interested in delving deeper into the original studies and experiments which the author has so brilliantly compiled.

With further discoveries in endocrinology, new work in physiological chemistry, and advances in the practical application of discoveries already made, there soon will be a place for new editions of this book; I shall await them with keen anticipation. But for today, and the immediate future, it has a great practical appeal and fulfills Dr. Graves' plan "to furnish a concrete picture of a complex subject."

GEORGE H. GARDNER

BOTH Dr. Osgood and Dr. Allison are well known for their excellent writings on the subject of orthopedic surgery. In their new contribution[2] they offer the reader a collection of lectures written especially for the advanced medical student and the general practitioner. They have tried to impart information as to the diagnosis and the treatment of diseases and lesions which are included in the subject of orthopedic surgery. They present the subject to the practitioner in order to help him to act intelligently in applying first aid and in recognizing various lesions and their underlying causes.

[1] FEMALE SEX HORMONOLOGY; A REVIEW. By William P. Graves, A.B., M.D., F.A.C.S. Philadelphia: W.B. Saunders Company, 1931.

[2] FUNDAMENTALS OF ORTHOPÆDIC SURGERY IN GENERAL MEDICINE AND SURGERY (HARVARD LECTURES). By Robert B. Osgood, M.D., F.A.C.S., and Nathaniel Allison, M.D., F.A.C.S. New York: The Macmillan Company, 1931.

The lectures have been rewritten several times during the past 6 years. The authors believe that class exercises in a specialty should include the fundamentals upon which depend reasonably accurate diagnoses and indicate immediate, appropriate treatment. They supplement the exercises by clinical work given to small groups of students.

These lectures reflect, to a considerable degree, much of the teachings of the late Dr. Robert W. Lovett.

The plan recommended by the authors is as follows: Each lecture is mimeographed and a copy is given to each student one week before the class exercise at which the subject contained is to be discussed. The students are advised to read each lecture and take notes therefrom, after which, the lecture is signed and returned before the exercise is given. The hour of the exercise is divided into three periods of twenty minutes each. During the first period which is called visual approach, the subject is amplified by the demonstration of clinical cases, pathological specimens and lantern slides. During the second period, called the deductive approach, the student is permitted to ask the lecturer questions relative to the written lecture previously given, and the clinical demonstration. During the third period, called the eductive approach, the students are quizzed on the written lecture.

The twelve lectures include the following: general joint phenomena, the reactions of developmental and adult bone, nutritional and growth disturbances; congenital deformities, cerebral and spastic palsy; obstetrical paralysis; Volkmann's deformity, Dupuytren's contracture; scoliosis, tuberculosis; anterior poliomyelitis; chronic rheumatic arthritis; traumatic affections of joints and bursæ; the relation of orthopedic surgery to industry; and body mechanics and statics.

In general, the three main causes for tissue changes in bones and joints are given as trauma, infection, and toxins. Arthritis is divided into Type I—atrophic arthritis; and Type II—hypertrophic arthritis.

Teachers of orthopedic surgery generally would consider that this subject cannot be covered in 12 lectures. The brief description of epiphyseal disturbances and especially their treatment would be criticized by most teachers. The reviewer was surprised to find no statement concerning the use of convalescent serum in the treatment of infantile paralysis in spite of the fact that the authors state that the orthopedic surgeon has no place in the treatment of this disease before paralysis occurs.

The authors use the term "obstetrical paralysis" for which the term "brachial birth palsy" would be a welcome substitute. In the discussion on Dupuytren's contracture, no mention is made of the important work of Kanavel.

The conception of the authors brings up an interesting pedagogical experiment which might be used as a guide for other teachers for this and other specialties.

PHILIP LEWIN

IN a compilation[1] of previously published articles, Granger includes his more recent observations with roentgenograms heretofore unpublished. The radiograms are unusually clear, the various sinuses being brought out and well delineated by the use of contrast opaque material injected into the sinuses of a dry skull. In this manner the 107 degree angle was determined as the best suitable for roentgenography of the posterior ethmoids and sphenoids. Emphasis and great reliance is placed upon the clearness or cloudiness of the "Granger line," a curved line extending from just below one anterior clinoid process to just below its fellow of the opposite side. If this line is distinct and clear cut, the sphenoids are normal. Even a small amount of pus will render it opaque and it is not obscured by pathology or absence of the frontal sinus.

Use is made of the Law and a combination of the Arcelin and the author's position in taking mastoid films. Cases demonstrating acoustic nerve tumors labyrinthitis, Bezold abscess, and periosteitis are shown. Mastoiditis in infants is diagnosed by the presence of a visible sinus plate in the absence of unusual pneumatization and a more sharply outlined sinus plate with absence of cell and spongy bone structure detail in the roentgenograph of older children and adults.

This work is a summary of the generally adopted methods in use for the examination of the sinuses and mastoids. A great deal of the work has been published before and the author now presents it in a thoroughly compact and easily assimilable form.

JOHN F. DELPH

[1] A RADIOLOGICAL STUDY OF THE PARA-NASAL SINUSES AND MASTOIDS. By Amédée Granger, K.C.B., K.C.I., M.D., F.A.C.R. Philadelphia: Lea and Febiger, 1932.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM. By Edward Meakin Livingston, B.Sc., M.D. New York: Paul B. Hoeber, Inc., 1932.

INTRACRANIAL TUMORS: NOTES UPON A SERIES OF TWO THOUSAND VERIFIED CASES WITH SURGICAL-MORTALITY PERCENTAGES PERTAINING THERETO. By Harvey Cushing. Springfield, Illinois, and Baltimore, Maryland: Charles C. Thomas, 1932.

DISEASES OF THE KIDNEY. By W. Girling Ball, F.R.C.S. (Eng.), and Geoffrey Evans, M.D.(Cantab.), F.R.C.P. (Lond.). Philadelphia: P. Blakiston's Son & Co. Inc., 1932.

THE PRACTITIONERS LIBRARY OF MEDICINE AND SURGERY. Vol. i, ANATOMY AND PHYSIOLOGY AS APPLIED TO PRACTICAL MEDICINE; AND vol. ii, THE TECHNIC OF PHYSICAL AND LABORATORY EXAMINATION IN CLINICAL MEDICINE. New York and London: D. Appleton and Company, 1932.

BIOLOGÍA Y PATOLOGÍA DE LA MUJER; TRATADO DE OBSTETRICA Y GINECOLOGÍA, PUBLICADO BAJO LA DIRECCIÓN DE LOS DOCTORES JOSEF HALBAN AND LUDWIG SEITZ. Traducido directamente del original alemán por Joaquín Núnez Grimaldos, con la colaboración técnica del Dr. D. Arcadio Sánchez López. Tomo ix. Madrid: Editorial Plus Ultra, 1932.

TRANSACTIONS OF THE AMERICAN GYNECOLOGICAL SOCIETY. Vol. lvi, 1931. Edited by Floyd E. Keene, M.D. St. Louis: The C. V. Mosby Company, 1932.

GEBURTSHELFER UND RÖNTGENBILD; ERWEITERUNG UND ERNEUERUNG DER GEBURTSHILFE DURCH DIE RÖNTGENDIAGNOSTIK. By Universitätsprofessor Dr. Wilhelm Liepmann and Dr. Gerhard Danelius. Berlin and Vienna: Urban & Schwarzenberg, 1932.

A TEXT-BOOK OF PSYCHIATRY; FOR STUDENTS AND PRACTITIONERS. By D. K. Henderson, M.D.(Edin.), F.R.F.P.S.(Glas.), and R. D. Gillespie, M.D.(Glas.), M.R.C.P., D.P.M.(Lond.), 3d ed. New York and London: Oxford University Press, 1932.

MANUAL OF BACTERIOLOGY. By Robert Muir, M.A., M.D., Sc.D., LL.D., F.R.S., and the Late James Ritchie, M.A., M.D., F.R.C.P.(Ed.). Revised by Carl H. Browning M.D., D.P.H., F.R.S., and Thomas J. Mackie, M.D., D.P.H. 9th ed. New York and London: Oxford University Press, 1932.

CANCER; WHAT EVERYONE SHOULD KNOW ABOUT IT. By James A. Tobey, Dr. P.H. With introductions by Joseph Colt Bloodgood, M.D., and H. L. Mencken. New York: Alfred A. Knopf, 1932.

THE TECHNIQUE OF THE NON-PADDED PLASTER CAST. By Fritz Schnek, M.D. With a Preface by Lorenz Böhler, M.D. Authorized English Translation by Douglas D. Toffelmier, M.D. Vienna: Wilhelm Maudrich, 1932.

RECONSTRUCTION OF THE BILIARY TRACT; A REVIEW OF ALL THE METHODS THAT HAVE BEEN EMPLOYED. By Edmund Horgan, M.D., M.S., F.A.C.S. New York: The Macmillan Company, 1932.

IKONOGRAPHIA UROLOGICA; IM AUFTRAGE DER DEUTSCHEN GESELLSCHAFT FÜR UROLOGIE. Edited by Alfred Rothschild, Victor Blum, and Friedrich Necker. Lieferung iv. Berlin: Verlag Georg Stilke, 1932.

COLLECTION DES INITIATIONS MÉDICALES. Published under the direction of Dr. A. Sézary. GYNÉCOLOGIE. By A. Laffont. Paris: Masson et Cie, 1932.

A TEXT-BOOK OF X-RAY THERAPEUTICS. By Robert Knox, M.D., C.M.(Edin.), M.R.C.S.(Eng.), L.R.C.P. (Lond.), M.I.E.E., D.M.R.E. Completed and edited by Walter M. Levitt, M.B.(Irel.), M.R.C.P.(Lond.), D.M.R.E.(Camb.). New York: The Macmillan Company; London: A. & C. Black, Limited, 1932.

METHODS AND PROBLEMS OF MEDICAL EDUCATION (TWENTIETH SERIES). New York: The Rockefeller Foundation, 1932.

MODERN GENERAL ANESTHESIA; A PRACTICAL HANDBOOK. By James G. Poe, M.D. 2d ed. rev. and enl. Philadelphia: F. A. Davis Company, 1932.

LABORATORY TECHNIQUE. By R. B. H. Gradwohl, M.D. St. Louis: Gradwohl School of Laboratory Technique, 1932.

THE PRACTICAL MEDICINE SERIES. OBSTETRICS. Edited by Joseph B. DeLee, A.M., M.D., GYNECOLOGY. Edited by J. P. Greenhill, B.S., M.D., F.A.C.S. Series 1931. Chicago: The Year Book Publishers, Inc., 1932.

THE PRACTICAL MEDICINE SERIES. GENERAL SURGERY. Edited by Evarts A. Graham, A.B., M.D., Series 1931. Chicago: The Year Book Publishers, Inc., 1932.

AMERICAN COLLEGE OF SURGEONS

THE ANNUAL OBLIGATION OF A LITERARY AND CLINICAL SURVEY

SPRING in a rural community marks the beginning of a period of unremitting labor, —plowing, planting, and cultivation,— arduous toil, holding out, however, the promise of a bountiful harvest in the Summer and Fall. To speak in the late Spring of making hay in the domain of medicine and surgery is as irrational as in the life of a rural community,—but in both situations it must be remembered that the harvest is dependent upon the activities of the preceding season. If the surgeon or internist is to meet the demands of the Fall months as completely equipped as possible for that very active period, it is well for him to prepare himself by making a careful survey of the cases which have been under his care during the past year. An investigation of his cases by groups will show him whether his records are sufficiently complete and accurate in every instance, whether the daily noting of certain additional factors might not have led to definite conclusions in a selected group of cases, or whether in other instances a slight change in technique would have produced a better end-result—a more perfectly functioning member. A study of the cases in the practice of an individual surgeon or the analysis of a series of similar cases in a hospital or clinic will stimulate interest and lead to the determining of valuable conclusions.

If the study is being carried on in a small hospital, where co-operation is the watchword of the institution, or in a larger one, where such a spirit is perhaps even more important, the investigation can assume such proportions as to involve practically all departments of the hospital: medicine, surgery, X-ray, anæsthesia, dietetics, record room, etc. The active co-operation of one or more representatives from each of the above mentioned staffs will contribute extensively to the success of the analysis both from the point of view of the consideration of the data actually available from the present records and also with respect to the presentation of practical suggestions for the modification of the records with the addition, elimination, and rearrangement of data so that the future study of other groups of cases may be facilitated.

Whether the more extensive investigation is undertaken or the simpler analysis of a group of cases under the doctor's own supervision, the individual or staff making such a study will need to be familiar with the details of other surveys. He will wish to know what points were considered important by other men in this country and abroad who have made similar analyses and what their conclusions may have been. He will be interested in knowing in how many of a certain series of 168 cases the end-results were improved and the reason for the exceptions. Whatever his problem it will be necessary for him to be familiar with the medical literature and in this phase of his study the Department of Literary Research of the College can be of assistance to him.

The staff of workers maintained by the Department of Literary Research of the American College of Surgeons is equipped to obtain from the medical literature whatever data is required by the professional man engaged in reviewing the literature in conjunction with an analysis of his cases or any other scientific study to which he may be devoting his attention. The staff includes workers trained in the preparation of bibliographies, abstracts, and translations upon medical subjects. If references are desired to articles on a specific subject, these can be supplied by the department covering the medical literature for any period of years as indicated by the one submitting the request: one, two, ten, or twenty years, or back to the beginning of the work on this subject. In some instances it is necessary to prepare a working bibliography upon a general subject and to check these references so as to eliminate the extraneous material and include brief notations upon the references in point. Whatever the need of the investigator in this field, it can be supplied by this group of trained workers experienced in gleaning data from the medical literature.

If abstracts and translations are desired, workers in the various foreign languages can provide them including material from the German, French, Spanish, Italian, Dutch, Russian, and Scandinavian languages. If it is advisable to have a complete translation from the foreign publica-

tion, this can be provided. If abstracts covering specified points only are necessary, the data can be furnished in accordance with the wishes of the one making the request.

It is the aim of the department to supply the needs of the investigator in so far as the medical literature affords opportunity. To facilitate the service of the department, blanks will be supplied upon request. The blank affords an opportunity for a definite statement of the subject, and the type of research desired: bibliography, abstracts, and translations, or package library. (The package library is a loan service which is free of charge. It includes those reprints which are available in the College collection. The material in this collection is not complete on any one subject, although in many instances it contains sufficient material for the speaker who is to make a brief address or discuss the paper of another investigator). The blank also gives an opportunity for indicating the phases of the subject which are of particular interest, the date at which the material is desired, and the appropriation which the investigator wishes to spend upon the research. With a specific date in mind at which the completed material is desired and a definite appropriation stated, the department will furnish as much data as possible for the time and money allotted in each instance. It is the aim of the department to furnish an accurate and scientific service, as complete as the individual investigator may desire—that any member of the profession, wherever he is located and however much he is pressed for time, may have the advantage of a survey of the literature as a background for the study of his own cases.

CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

ALLEN B. KANAVEL, Chicago, *President* J. BENTLEY SQUIER, New York, *President-Elect*
FRANKLIN H. MARTIN, Chicago, *Director-General*
EVARTS A. GRAHAM, St. Louis, *Chairman, Committee on Arrangements*

PRELIMINARY PROGRAM FOR THE ST. LOUIS CLINICAL CONGRESS

IN the following pages will be found a preliminary program of the clinics and demonstrations to be given in the hospitals and medical schools of St. Louis during the twenty-second annual Clinical Congress of the American College of Surgeons, October 17–21 as prepared by the Committee on Arrangements. The surgeons of St. Louis are keenly interested to provide a complete showing of the surgical activities of that city, with its two splendid medical schools and many fine large hospitals.

The final program will include operative clinics and demonstrations in all branches of surgery—general surgery, gynecology, obstetrics, orthopedics, urology, proctology, and surgery of the eye, ear, nose, and throat. It will be noted that clinics are scheduled for the afternoon of Monday, October 17, beginning at 2 o'clock, and for the mornings and afternoons of each of the four following days.

The program as published at this time is merely an outline or basis for the final program. During the months preceding the Congress the hospital schedules will be revised and amplified under the direction of the Committee on Arrangements so that in its final form the program will present a completely detailed schedule of the clinical work to be demonstrated.

A demonstration of the modern methods in the treatment of fractures will be a feature of the clinical program. At several of the hospitals plans are being made for a comprehensive showing of the various methods used and the results obtained in the treatment of fractures which form so large a part of the surgical work in large cities and industrial centers. Other important features of the clinical program include demonstrations in the treatment of cancer by surgery, radium and X-ray; the rehabilitation by surgery and physiotherapy of patients injured in industrial, railway, and automobile accidents, etc.

EVENING MEETINGS

An outline of the programs for a series of five evening meetings to be held in the ballroom of the Jefferson Hotel, as arranged by the Central Executive Committee, will be found in the following pages. At the presidential meeting on Monday evening the president-elect, Dr. J. Bentley Squier, of New York, will be inaugurated and deliver the annual address. This will be followed by the John B. Murphy oration in surgery by Sir William I. DeCourcy Wheeler, of Dublin, Ireland.

At the annual Convocation of the College on Friday evening the 1932 class of candidates for Fellowship in the College will be received. Dr. J. Bentley Squier, of New York, will deliver the annual address, and Robert A. Millikan, director of the Norman Bridge Laboratory of Physics of the California Institute of Technology, will deliver the Fellowship address.

The annual fracture oration will be delivered by Dr. Philip D. Wilson, of Harvard Medical School and the Massachusetts General Hospital, Boston.

Programs for meetings on Tuesday and Thursday evenings in the ballroom of the Statler Hotel at which a number of outstanding American ophthalmologists and otolaryngologists will present papers of interest to those who practice those specialties are being prepared and will be published in an early issue.

FEATURES OF THE PROGRAM

A symposium on cancer and a conference devoted to the consideration of the essentials in the organization and administration of cancer clinics, under the auspices of the Committee on the Treatment of Malignant Diseases, are features of the program at headquarters on Thursday.

A conference on traumatic surgery, under the auspices of the Board on Industrial Medicine and

Traumatic Surgery, is being arranged for Friday with a program which will include presentations by leaders in industry as well as surgeons and hospital administrators.

The newest surgical films, both sound and silent, will be shown daily in the ballroom of the Statler Hotel. An extensive program of film contributions will be presented.

HOSPITAL CONFERENCE

An interesting program of papers, round table conferences and practical demonstrations dealing with many of the problems related to the hospital standardization program of the College and hospital efficiency in general is being prepared for the annual hospital conference which opens at 10 o'clock on Monday morning in the ballroom of the Jefferson Hotel. The conference continues Monday afternoon and on Tuesday and Wednesday both morning and afternoon. The program for this conference is planned to interest surgeons, hospital trustees, executives, and nurses, and an invitation to attend is extended to all persons interested in the hospital field.

HEADQUARTERS

General headquarters for the Clinical Congress will be established at the Jefferson Hotel, 12th and Locust streets, where the ballroom, Crystal and Ivory rooms and foyers adjacent thereto on the mezzanine and second floors have been reserved for the exclusive use of the Congress for scientific meetings, conferences, registration and ticket bureaus, bulletin boards, executive offices, scientific and technical exhibitions, etc. The ballroom of the Statler Hotel, at Washington and 9th streets, will be utilized daily for film exhibitions and certain scientific sessions.

ADVANCE REGISTRATION

Attendance at the St. Louis session will be limited to a number that can be comfortably accommodated at the clinics—the limit of attendance being based upon the result of a survey of the amphitheaters, operating rooms and laboratories in the hospitals and medical schools to determine their capacity for accommodating visitors. It will be necessary, therefore, for those who wish to attend the Clinical Congress in St. Louis to register in advance.

Attendance at all clinics and demonstrations will be controlled by means of special clinic tickets, which plan provides an efficient means for the distribution of the visiting surgeons among the several clinics and insures against overcrowding, as the number of tickets issued for any clinic will be limited to the capacity of the room in which that clinic will be given.

A registration fee of $5.00 is required of each surgeon attending the annual Clinical Congress, such fees providing the funds with which to meet the expenses of the meeting. To each surgeon registering in advance a formal recipt for the registration fee is issued, which receipt is to be exchanged for a general admission card upon his registration at headquarters. This card, which is non-transferable, must be presented in order to secure clinic tickets and admission to the evening meetings.

REDUCED RAILWAY FARES

The railways of the United States and Canada have authorized reduced fares on account of the St. Louis session of the Clinical Congress so that the total fare for the round trip will be one and one-half the ordinary first-class one-way fare. To take advantage of the reduced rates it is necessary to pay the full one-way fare to St. Louis, procuring from the ticket agent when purchasing ticket, a "convention certificate", which certificate is to be deposited at headquarters for the signature of the general manager of the Clinical Congress and the visé of a special agent of the railways. Upon presentation of a viséd certificate to the ticket agent in St. Louis not later than October 25, a ticket for the return journey by the same route as traveled to St. Louis may be purchased at one-half the one-way fare.

In the eastern, central, and southern states and eastern provinces of Canada tickets may be purchased between October 14 and 20; in other sections of the United States and Canada at earlier dates. The return journey must be completed within thirty days from date of sale of ticket to St. Louis.

The reduction in fares does not apply to Pullman fares nor to extra fares charged for passage on certain trains. Local railroad ticket agents will supply detailed information with regard to dates of sale, rates, routes, etc. Stop-overs on both the going and return journeys may be had within certain limits.

Full fare must be paid from starting point to St. Louis, and it is essential that a "convention certificate" be obtained from the agent from whom the ticket is purchased. These certificates are to be signed by the general manager of the Clinical Congress and viséd by a special railroad agent at Clinical Congress headquarters on or before October 21. No reduction in railroad fares can be secured except in compliance with the regulations outlined and within the dates speci-

fied. It is important to note that the return trip must be made by the same route as that used in going to St. Louis and that the certificate must be deposited at headquarters during the meeting and return ticket purchased not later than October 25.

An exception to the above arrangement is to be noted in the case of persons traveling from points in certain far western states and British Columbia, who will be able to purchase round trip summer excursion tickets which will be on sale up to and including October 15 with a final return limit of October 31. The summer excursion fare is somewhat lower than the convention fare mentioned above, but is available only in certain of the far western states and British Columbia. Tickets sold at summer excursion rates permit traveling to St. Louis by way of a direct route and returning by way of another direct route with liberal stop-over privileges.

COMMITTEE ON ARRANGEMENTS

Evarts A. Graham, Chairman
F. A. Jostes, Secretary

Executive Committee

Fred Bailey
M. B. Clopton
William T. Coughlin
L. W. Dean
Ellis Fischel
Evarts A. Graham
Roland Hill
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Otto Schwarz
Alphonse M. Schwitalla
M. G. Seelig
Omar R. Sevin
Carroll Smith
Max Starkloff
Ross Woolsey
O. B. Zeinert

PRELIMINARY PROGRAM FOR EVENING MEETINGS

BALLROOM, JEFFERSON HOTEL

Presidential Meeting—Monday Evening

Address of Welcome: EVARTS A. GRAHAM, M.D., St. Louis, Chairman, Committee on Arrangements.

Introduction of Foreign Guests.

Address of Retiring President: Intangibles in Surgery. ALLEN B. KANAVEL, M.D., Chicago.

Inaugural Address: J. BENTLEY SQUIER, M.D., New York.

The John B. Murphy Oration in Surgery: SIR WILLIAM I. DE COURCY WHEELER, M.S., F.R.C.S.I., Dublin, Ireland.

Tuesday, Wednesday, and Thursday Evenings

Symposium on Surgery of the Large Bowel:

Diverticulitis of the Large Bowel. VERNON C. DAVID, M.D., Chicago.

The Hopeful Prognosis of Carcinoma of the Colon. FRED W. RANKIN, M.D., Rochester, Minn.

Gynecological Symposium:

The Results of Irradiation in the Treatment of Functional Uterine Bleeding Based Upon a Study of Four Hundred Cases. FLOYD E. KEENE, M.D., Philadelphia.

The Detection of Clinically Latent Cancer of the Cervix. WILLIAM P. GRAVES, M.D., Boston.

Fracture Oration. PHILIP D. WILSON, M.D., Boston.

Inflammation. SIR GEORGE LENTHAL CHEATLE, K.C.B., C.V.O., F.R.C.S., London, England.

Bronchiectasis and Its Treatment by Lobectomy in One Stage. HAROLD BRUNN, M.D., San Francisco.

A Discussion of Some Principles Involved in the Pathology and Treatment of Empyema Thoracis. JOSEPH A. DANNA, M.D., New Orleans.

An Experimental and Clinical Study of the Use of Radium in the Brain. LOYAL DAVIS, M.D., and MAX CUTLER, M.D., Chicago.

Some Observations on Appendicitis: A Review of Four Thousand Appendectomies. J. M. T. FINNEY, JR., M.D., Baltimore.

Convocation—Friday Evening

Invocation.

Conferring of Fellowships.

Conferring of Honorary Fellowships.

Presidential Address. J. BENTLEY SQUIER, M.D., New York.

Fellowship Address: Some New Things in Physics. ROBERT A. MILLIKAN, Ph.D., Sc.D., LL.D., Director, Norman Bridge Laboratory of Physics, California Institute of Technology, Pasadena.

PRELIMINARY CLINICAL PROGRAM

GENERAL SURGERY, GYNECOLOGY, OBSTETRICS, ORTHOPEDICS, UROLOGY, PROCTOLOGY, SURGICAL PATHOLOGY, ETC.

WASHINGTON UNIVERSITY

Barnes Hospital

Evarts A. Graham, M. B. Clopton, A. O. Fisher, G. H. Copher, W. H. Cole, Dr. Allen, W. R. Rainey, I. Y. Olch, R. Elman and P. Heinbecker—9, daily. General surgical operations.

Ernst Sachs and Roland M. Klemme—9, daily. Neurological surgery.

John R. Caulk, D. K. Rose, J. H. Sanford, Otto J. Wilhelmi and V. R. Deakin—9, daily. Genito-urinary surgery.

Vilray P. Blair, J. B. Brown and W. G. Hamm—9, daily. Oral and plastic surgery.

J. A. Key, Archer O'Reilly, J. W. Stewart, T. P. Brookes and F. A. Jostes—9, daily. Orthopedic operations.

H. S. Crossen, Otto Schwarz, F. J. Taussig, Q. U. Newell, C. D. O'Keefe and Robert Crossen—9, daily. Gynecological operations.

Medical and surgical staffs—9 and 2, daily. Clinical demonstrations.

St. Louis Maternity Hospital

O. H. Schwarz, G. D. Royston, F. P. McNalley, T. K. Brown and R. Paddock—9, daily. Obstetrical operations.

H. S. Crossen, Otto H. Schwarz, G. D. Royston, Q. U. Newell, F. P. McNalley, O. S. Krebs, C. D. O'Keefe, T. K. Brown, C. R. Wegner, R. Paddock, R. J. Crossen, M. A. Roblee and J. E. Hobbs—2, daily. Demonstration of obstetrical and gynecological cases and specimens.

St. Louis Children's Hospital

W. M. Marriott, J. V. Cooke, A. F. Hartmann, T. C. Hempelmann and Hugh McCulloch—2, daily. Clinical demonstrations.

Mallinckrodt Radiological Institute

Sherwood Moore, J. W. Larimore, O. C. Zink, M. G. Seibel and Dr. Wilson—9 and 2, daily. Clinical demonstrations.

ST. LOUIS COUNTY HOSPITAL

Tuesday

F. A. Jostes—9. Orthopedic clinic.

Wednesday

E. L. Dorsett—9. Gynecology.

Thursday

W. E. Leighton—9. General surgery.

Friday

F. L. Davis—9. Genito-urinary surgery.

U. S. VETERANS' HOSPITAL

Tuesday

S. L. Filkins, P. H. Finot and J. E. Wheeler—9. General surgical operations.

ST. LOUIS UNIVERSITY

St. Mary's Hospital

Tuesday

William T. Coughlin—9. Brain tumor; carcinoma of the breast.

John Stewart—9. Stomach and duodenal ulcer.

W. W. Graves and Leroy Sante—9. Brain tumor and duodenal ulcer.

Phil Hoffmann, Franklin Albrecht and Carl Vohs—2. Orthopedic clinic.

Wednesday

George Gellhorn and William Kerwin—9. Gynecological operations, prolapse of uterus, carcinoma of uterus, Cæsarean section.

Leroy Sante—9. The X-ray in gynecology.

William D. Collier—9. Demonstration of gynecologica specimens.

Thursday

William E. Leighton—9. Cancer of the neck.

Louis Rassieur—9. Gall-bladder operations.

Ralph Kinsella and William D. Collier—9. Demonstration of gall-bladder cases.

C. E. Burford and Joseph Glenn—2. Nephropexy.

Friday

Carroll Smith—9. Goiter operation.

Charles Sherwin—9. Carcinoma of the breast.

Ralph A. Kinsella and William D. Collier—9. Goiter cases.

H. H. Kramolowsky and George H. Koenig—2. General surgical operations and demonstration of cases.

St. John's Hospital

Monday

Staff—2. Dry clinic, bone cases. A. W. Ham: Bone development. A. E. Horwitz and C. Lindeman: Parkes disease. Leo Will: Fractures. Joseph Peden: X-ray demonstration of bone cases.

W. H. Vogt and associates—2. Obstetrical clinic.

Tuesday

B. Lewis, G. Carroll, Leo Bartels, C. D. Pickrell, G. H. Koenig, J. M. Schattyn and Robert F. Hickey—9. Urological operations.

O. P. J. Falk and Anthony Brennan—9. Discussion of diagnostic and medical aspects of urological cases.

Staff—2. Dry clinic, diseases of the lungs. J. L. Marder: Carcinoma of lungs. B. McMahon: Abscess of lungs. A. McMahon: Heart and lungs in surgical cases. George Gafney: Empyema.

Wednesday

L. M. Riordan, Percy H. Swahlen, William Vogt and M. Weis—9. Gynecological operations.

Staff—9. General surgical operations. William P. Glennon: Gall-bladder surgery. J. McHale Dean: Stomach and intestinal operations. I. H. Boemer: Abdominal surgery. G. T. Gafney: Carcinoma of the breast. W. T. Coughlin: Brain surgery. A. McMahon and J. J. Hammond: Discussion of diagnostic and medical aspects of these cases.

C. H. NEILSON, A. P. MUNSCH, J. McH. DEAN, A. McMAHON, O. FALK and I. H. BOEMER—2. Borderline medical and surgical cases.
C. H. NEILSON, F. KRAMER, J. McFADDEN, W. P. GLENNON, J. McH. DEAN and DR. ALLEN—2. Symposium on goiter.

Thursday

B. LEWIS—9. Urological operations.
W. VOGT—9. Gynecological operations.
J. McH. DEAN—9. Stomach and intestinal operations.
W. P. GLENNON—9. Goiter operation.
W. K. McINTYRE—9. Rectal operation.
E. H. BOWDERN—9. Demonstration of anæsthesia methods and apparatus.
A. P. MUNSCH and H. G. BRISTOW—9. Discussion of diagnostic and medical aspects of these cases.
Staff—2. Dry clinic. J. P. COSTELLO: Diagnosis of acute abdominal conditions in children. R. HYLAND: Traumatic surgery. J. McFADDEN: Neurological aspects of traumatic surgery. W. GALLAGHER: Treatment of varicose ulcers.
O. P. J. FALK, J. HAMMOND and WILLIAM GALLAGHER—2. Symposium on gall-bladder diseases. R. HYLAND: The acute surgical abdomen.

Friday

P. H. SWAHLEN and H. J. RINGO—9. Gynecological operations.
WILLIAM GALLAGHER—9. Abdominal operations.
T. R. KENNEDY—9. General surgery.
FRED BAILEY—9. Abdominal surgery.
A. J. RAEMDONCK and R. F. BARNES—9. Discussion of diagnostic and medical aspects of these cases.
A. WERNER—2. Endocrine disturbance.
J. A. HARDY and WILLIAM VOGT—2. Ectopic gestation.
A. E. HORWITZ—2. Orthopedic surgery.

FIRMIN DES LOGES HOSPITAL

Tuesday

E. A. DOISY—9. Ovarian extracts.
E. L. SHRADER—9:15. Theelin and ovarian extracts in coagulation.
A. A. WERNER—9:30. The effect of theelin on castrates.
J. B. MITCHELL—9:50. The action of theelin and theelol on fowl.
G. O. BROUN—10:10. Theelin and ovarian extracts in epilepsy.
W. D. COLLIER—10:30. The effect of theelin on the genital tract of the female white rat.

Wednesday

ALBERT KUNTZ—9. Autonomic nervous system in relation to surgery.
K. CHRISTIANSEN—9:30. The autonomic nervous system and special senses.
A. W. HAM—9:45. Calcium metabolism in bone and bone development.
R. A. KINSELLA—10:30. Bacterial endocarditis.

Thursday

A. H. HERTZMAN and F. E. FRANKE—9. Demonstration and discussion of cerebral circulation.
JOHN AUER—9:45. Studies on the contraction of fibrin and fibrinoid substances.
A. P. BRIGGS—10:05. Newer aspects of nephritis.
W. H. GRIFFITH—10:35. Food constitution in relation to food consumption (appetite).

Friday

ALBERT KUNTZ—9. Structural changes in the autonomic ganglia and ganglion cells associated with certain diseases.
PHILIP KATZMAN—9:30. Anterior pituitary hormone.
M. S. FLEISHER and L. R. JONES—9:50. Serum sickness in rabbits.
G. O. BROUN and H. L. LANGE—10:10. Studies on pernicious anæmia.

ST. ANTHONY'S HOSPITAL

Tuesday

W. GAYLER—9. Gynecological clinic.
E. H. RUND—9. Hysterectomy.
J. E. FERRIS—10:30. Gall-bladder surgery.
RUBEN SMITH—10:30. Hernia operations.

Wednesday

N. A. SCHNEIDER—9. Hernia operations.
NEIL MOORE and E. SEXTON—9. Diseases of the kidneys.
WILLIS YOUNG—10:30. Plastic surgery.
M. J. PULLIAM—10:30. Appendectomy.

Thursday

H. S. McKAY, J. C. LYTER, D. COLLIER, M. J. PULLIAM, R. M. S. BARRETT and P. NEUN—9. Stomach and gall-bladder operations; consideration of medical and pathological aspects; choice of anæsthetics.

Friday

H. S. McKAY, M. J. PULLIAM, R. M. S. BARRETT and P. NEUN—9. General surgical clinic; demonstration of pathological specimens, lantern slides.

MOUNT ST. ROSE SANITARIUM

Tuesday

Symposium on Medical and Surgical Aspects of Pulmonary Tuberculosis

C. L. BOISLINIERE—9. Diagnosis of pulmonary tuberculosis.
E. H. KESSLER—9:20. Roentgen findings in pulmonary tuberculosis.
ALPHONSE McMAHON—9:40. Differential diagnosis of toxic thyroid and pulmonary tuberculosis.
A. HENSKE—10:30. Pneumothorax in pulmonary tuberculosis.
C. W. EHLERS—10:50. Oleothorax in pulmonary tuberculosis.
J. L. MUDD—11:10. Surgical treatment of pulmonary tuberculosis.

Wednesday

J. L. MUDD—9. Thoracoplasty and phrenicectomy.

Thursday

J. L. MUDD—9. Thoracoplasty and phrenicectomy.
J. L. MUDD—2:30 Exhibition of postoperative patients.

Friday

J. L. MUDD and C. W. EHLERS—9. Demonstration of pneumothorax, oleothorax and phrenicectomy cases

FRISCO EMPLOYES' HOSPITAL

Thursday

R. A. WOOLSEY—9. Back injuries and back conditions.

Friday

R. A. WOOLSEY—9. General surgical operations.

JEWISH HOSPITAL

Tuesday

ELLIS FISCHEL, ERNST JONAS and J. PROBSTEIN—9. General surgery.
SAMUEL NEWMAN—9. Rectal surgery.
H. EHRENFEST, F. J. TAUSSIG, S. A. WEINTRAUB, GROVER LIESE, S. F. ABRAMS and Dr. PATTON—2. Obstetrical clinic.
Drs. GREY and SOMOGYI—2. Demonstration and discussion of experimental work of surgical significance.

Wednesday

R. M. KLEMME—9. Neurosurgical clinic.
H. EHRENFEST, F. J. TAUSSIG, S. A. WEINTRAUB, GROVER LIESE, S. F. ABRAMS and Dr. PATTON—9. Gynecological operations.
Drs. SINGER, SIMON and FRANK—2. Medical and surgical thoracic clinic with demonstration of unusual X-ray films.

Thursday

MAX W. MYER, HARRY SANDPERL, E. V. M. MASTIN and E. K. DIXON—9. General surgery.
B. MAY, D. K. ROSE and MCCLURE YOUNG—9. Genito-urinary surgery.
MEDICAL STAFF—2. Pre-operative medical care of patients.
PAUL LOWENSTEIN—3. Technique of injection of varicose veins.

Friday

ELLIS FISCHEL, WILLARD BARTLETT and PAUL LOWENSTEIN—9. General surgery.
F. H. ALBRECHT, FRED JOSTES and J. A. KEY—9. Orthopedic surgery.
S. GREY—2. Pathological demonstration.
P. C. SCHNOEBELEN—3. X-ray demonstration of gastro-intestinal lesions.
B. MAY, D. K. ROSE and MCCLURE YOUNG—2. Urological dry clinic.

ST. LOUIS CITY HOSPITAL

Monday

W. H. VOGT, PERCY H. SWAHLEN, T. R. AYARS and W. J. HANS—2. Obstetrical clinic.

Tuesday

MAX MYER, CHARLES F. SHERWIN and HENRY HASSETT—9. General surgery.
W. J. DOYLE and J. J. LINK—9. General surgery.
ROLAND HILL, FRANCIS REDER and THOMAS S. WIMBER—9. Industrial and traumatic surgery, dry clinic.
GRAYSON CARROLL, GEORGE H. KOENIG and CLARENCE MARTIN—2. Genito-urinary clinic.

Wednesday

EMMETT RUND, WILLIAM STUDE and S. A. WEINTRAUB—9. Gynecological clinic.
H. H. HELBING, C. W. GAERTNER, A. V. MARQUARDT and W. H. CLITHERO—9. Gynecological clinic.
JOHN W. STEWART, CHARLES F. SHERWIN, CHARLES WOLFF, A. E. HORWITZ and E. L. MORSE—9. Fracture clinic.

Thursday

JOHN W. STEWART and J. L. FERRIS—9. General surgery.
FRANCIS REDER, J. W. THOMPSON and ROLAND S. KIEFFER—9. General surgery.
FRANK J. TAINTER, WALTER C. G. KIRCHNER and W. J. DOYLE—9. Penetrating wounds of the chest and abdomen, dry clinic.
H. H. KRAMOLOWSKY and BENJAMIN F. MAY—2. Genito-urinary clinic.
H. G. LUND and P. N. DAVIS—2. Genito-urinary clinic.

Friday

FRANK J. TAINTER and W. J. GALLAGHER—9. General surgery.
ROLAND HILL, THOMAS S. WIMBER and N. M. FREUND—9. General surgery.
MAX MYER and LEROY SANTE—9. Surgical and radiological treatment of cancer.

BARNARD FREE SKIN AND CANCER HOSPITAL

Tuesday

FRED J. TAUSSIG, S. S. LEVIN, E. S. AUER and FRED EMMERT—9. Surgery and radium therapy in cancer of the uterus and vulva.
FRED J. TAUSSIG, GEORGE GELLHORN, S. S. LEVIN, E. S. AUER, FRED EMMERT, KATE SPAIN and MARION WACHOWIAK—2. Malignancy index in gynecological cancer; technique of vulvar operations; exhibition of specimens.

Wednesday

ELLIS FISCHEL, CHARLES F. SHERWIN and GEORGE GAFNEY—9. Radical surgery and interstitial radium therapy.
D. P. BARR, C. M. STROUD and E. C. ERNST—2. Internal medicine and radiography in relation to cancer.

Thursday

GEORGE GELLHORN, S. S. LEVIN, E. S. AUER, FRED EMMERT, KATE SPAIN and MARION WACHOWIAK—9. Surgery and radium therapy in cancer of the uterus.
M. G. SEELIG, L. H. JORSTAD and E. C. ERNST—2. Demonstration of the production of tar cancer; pathological specimens, X-rays and photomicrographs of unusual problems in malignancy; specimens of crown gall in plants produced by bacillus tumefaciens; studies of mitochondria in cancer; reticulum in cancer growth.

Friday

W. E. LEIGHTON, GRAYSON CARROLL, THOMAS M. MARTIN and J. C. LANDREE—9. Surgical cancer therapy.
M. F. ENGMAN, RICHARD WEISS, A. H. CONRAD, C. V. LANE and M. F. ENGMAN, JR.—2. Amœbic and phagedenic ulcers and ulcers of unknown cause, presentation of cases, lantern slides.

SHRINERS' HOSPITAL

Tuesday

Staff—9. Orthopedic operations.
Staff—2. Orthopedic clinic.

Wednesday

Staff—10. Orthopedic end-results.
Staff—2. Orthopedic end-results.

Thursday

Staff—9. Orthopedic operations.
Staff—2. Orthopedic end-results.

Friday

Staff—10. Orthopedic end-results.

MISSOURI BAPTIST HOSPITAL

Monday

C. H. SHUTT—2. General surgery.
J. S. YOUNG—2. Radiology.
M. L. KLINEFELTER—2. Demonstration of pathologic fractures.
GEORGE IVES—3. Cytologic study of cancer.
R. M. KLEMME—3. Neurosurgery.

Tuesday

E. L. DORSETT—9. Gynecological operations.
M. L. KLINEFELTER—9. Bone and joint surgery.
J. E. GLENN—9. Genito-urinary surgery.
H. TALBOTT—9. General surgery.
W. BARTLETT and W. BARTLETT, JR.—9. Goiter surgery.
R. J. CROSSEN—2. Gynecology.
D. K. ROSE—2. Genito-urinary clinic.
GEORGE IVES—2. Demonstration of method of blood transfusion.
W. E. WERNER—3. Goiter etiology.

Wednesday

C. H. SHUTT—9. General surgery.
M. L. KLINEFELTER—9. Bone and joint surgery.
C. E. BURFORD—9. Genito-urinary surgery.
J. B. BROWN—9. Plastic surgery.
W. BARTLETT, W. BARTLETT, Jr. and J. C. LYTER—9. General surgery.
R. K. ANDREWS, O. H. CAMPBELL, C. E. GILLILAND, L. R. HEMPLEMAN, S. D. GRANT, and J. C. LYTER—2. Internists' symposium on surgical failures.
C. E. BURFORD—2. Genito-urinary surgery.

Thursday

R. S. KEIFFER—9. General surgery.
M. L. KLINEFELTER—9. Bone and joint surgery.
W. S. WIATT—9. General surgery.
D. K. ROSE—9. Genito-urinary surgery.
W. BARTLETT and W. BARTLETT, JR.—9. Goiter surgery.
S. I. SCHWAB and W. BARTLETT—2. Psychiatric aspects of surgery.
S. B. GRANT—2. The heart in goiter cases.
J. P. ATLHEIDE—2. Genito-urinary surgery.
J. B. BROWN—2. Industrial surgery.
J. P. MURPHY—3. The larynx in goiter cases.
J. S. YOUNG—3. Physiotherapy.

Friday

M. L. KLINEFELTER—9. Bone and joint surgery.
H. M. MOORE—9. General surgery.
Q. U. NEWELL—9. Gynecological operations.
R. M. KLEMME—9. Neurosurgical operations.
W. BARTLETT, JR.—9. General surgery.
W. L. CONRAD and H. F. D'OENCH—2. Dental surgery.
E. L. DORSETT—2. Gynecology.
W. BARTLETT, JR.—3. Chief safety factor in goiter surgery.

ST. LUKE'S HOSPITAL

Tuesday

J. H. SANFORD, JOHN R. CAULK, OTTO WILHELMI, JOHN PATTON and C. E. BURFORD—9. Genito-urinary surgery.
D. STUTZMAN—10. Genito-urinary clinic.
J. H. SANFORD—11. Diagnosis and treatment of kidney lesions.
O. C. ZINK—11. X-ray interpretation.
R. M. KLEMME—11:30. Brain abscess.

Wednesday

C. D. O'KEEFE, OTTO KREBS, ROBERT CROSSEN and EDGAR SCHMITZ—9. Gynecological operations.
J. VAUGHN and GREY JONES—10. Obstetrical and gynecological clinic.
C. D. O'KEEFE—11. Ovarian cysts.
OTTO KREBS—11:30. Sterility.

Thursday

R. M. KLEMME—9. Neurological surgery.
A. O'REILLY and J. E. STEWART—9. Orthopedic surgery.
J. E. STEWART—10:30. Orthopedic clinic.
J. E. STEWART—11:30. Fractures of upper third of femur.
O. C. ZINK—11:30. X-ray demonstration.

Friday

O. R. SEVIN—9. General surgery.
L. KEYES, C. E. HYNDMAN, E. V. MASTIN and E. K. DIXON—10. General surgical clinic.

LUTHERAN HOSPITAL

Monday

T. P. BROOKES—2. Dislocations of the cervical spine, complications; demonstration of cases, lantern slides.
H. N. GLICK—3. Surgical consideration of structure of petrous pyramid; demonstration of cases, lantern slides.

Tuesday

J. L. HUTTON—9. General surgical operations.
J. L. HUTTON—2. Congenital megacolon (Hirschsprung's disease); demonstration of cases following surgical treatment.

Wednesday

R. E. SCHLUETER—9. General surgical operations.
H. A. HANSER and T. H. HANSER—9. General surgical operations with spinal anæsthesia.
H. A. HANSER and T. H. HANSER—2. Embolectomy, demonstration of cases.
E. W. SPINZIG—3. Roentgenological diagnosis of spontaneous and traumatic pneumoperitoneum.

Thursday

J. L. HUTTON—9. General surgical operations.

Friday

H. A. HANSER and T. H. HANSER—9. General surgical operations.
R. E. SCHLUETER—9. General surgical operations.

U. S. MARINE HOSPITAL

Monday

J. E. SMITH—2. Clinical demonstration of abscess of lung.

Tuesday

W. M. JONES—10. General surgical operations.
W. L. COREY—2. Clinical demonstration of abdominal tumor with obstruction of transverse colon.

Thursday

W. M. JONES—10. General surgical operations.
J. T. DELOUGHERTY—2. Clinical demonstration of pyloric obstruction of stomach.

Friday

W. M. JONES—10. General surgical operations.

DEACONESS HOSPITAL

Monday

HERMAN NEIDERT, FRANCIS REDER, FRED BAILEY, JOHN C. MORFIT, ROBERT E. SCHLUETER and A. R. SHREFFLER—2. Medico-surgical dry clinics.

Tuesday

FRED W. BAILEY, WILLIAM H. NORTON, A. V. MARQUARDT, LEO A. WILL and J. EDGAR STEWART—9. General surgery and orthopedic operations.

A. R. SHREFFLER, EDWIN SCHISLER, M. L. KLINEFELTER, GUY SIMPSON and N. C. GAYLOR—2. Medico-surgical clinical demonstrations.

Thursday

E. LEE DORSETT, N. C. GAYLOR, JOHN W. STEWART, FRED W. BAILEY, FRANCIS REDER and HERMAN NEIDERT—9. General surgery and neurological operations.

L. H. HEMPLEMAN, LEO BROOKS, CLAUDE PICKRELL, CHARLES A. STONE, JOHN C. MORFIT, M. F. ARBUCKLE and FRED C. SIMON—2. Clinical demonstrations.

MISSOURI PACIFIC HOSPITAL

Tuesday

O. B. ZEINERT and associates—9. General surgical operations.

W. P. ELMER and associates—9. Medical diagnostic clinic.

Wednesday

I. H. BOEMER and associates—9. Abdominal surgery.

W. K. MUELLER and associates—9. Roentgenological clinic.

H. J. SCHERCK and associates—9. Genito-urinary surgery.

Thursday

A. O. FISHER and associates—9. General surgical operations.

W. P. ELMER and associates—9. Medical diagnostic clinic.

Friday

O. B. ZEINERT and associates—9. General surgical operations.

W. K. MUELLER and associates—9. Roentgenological clinic.

J. H. SANFORD and associates—9. Genito-urinary surgery

SURGERY OF THE EYE, EAR, NOSE, AND THROAT

WASHINGTON UNIVERSITY

BARNES HOSPITAL

Monday

FREDERICK O. SCHWARTZ—2. Eye operations.

Tuesday

M. F. ARBUCKLE and A. W. PROETZ—11. Otolaryngological operations.

MEYER WIENER—2. Eye operations.

Wednesday

HARVEY J. HOWARD—2. Eye operations.

Thursday

LAWRENCE T. POST—2. Eye operations.

Friday

A. J. CONE, B. J. MCMAHON and WILLIAM L. HANSON—9. Otolaryngological operations.

J. B. COSTEN, L. J. BIRSNER and F. K. HANSEL—11. Otolaryngological operations.

H. ROMMEL HILDRETH—2. Plastic surgery of the eye.

MCMILLAN HOSPITAL

Staff—Daily, 9:00 and 10:30. Laboratory demonstrations.

LAWRENCE T. POST: Slit lamp demonstration.

WILLIAM E. SHAHAN: Physiological apparatus (including thermophore).

WILLIAM F. HARDY: Ocular muscles.

H. ROMMEL HILDRETH: Ultraviolet light therapy.

B. Y. ALVIS: Cylinder skiascopy.

M. HAYWARD POST: Advanced refraction technique.

FREDERICK E. WOODRUFF: Ophthalmoscopy.

MAX W. JACOBS: Ocular changes during pregnancy.

J. E. JENNINGS: Color vision tests.

ROY E. MASON: Industrial ophthalmology.

Monday

HOWARD C. KNAPP—2. Ocular tuberculosis clinic.

MEYER WIENER—2. Diagnostic eye clinic.

WILLIAM M. JAMES—3. Ocular syphilis clinic.

Tuesday

M. HAYWARD POST—2. Diagnostic eye clinic.

Wednesday

HOWARD C. KNAPP—2. Ocular tuberculosis clinic.

WILLIAM E. SHAHAN—2. Diagnostic eye clinic.

WILLIAM M. JAMES—3. Ocular syphilis clinic.

Thursday

WILLIAM F. HARDY—2. Diagnostic eye clinic.

Friday

HOWARD C. KNAPP—2. Ocular tuberculosis clinic.

LAWRENCE T. POST—2. Diagnostic eye clinic.

WILLIAM M. JAMES—3. Ocular syphilis clinic.

OSCAR JOHNSON INSTITUTE

Staff—Daily, 9:00 and 10:30. Laboratory demonstrations.

HARVEY D. LAMB: Pathology of the eye.

WILLIAM M. JAMES: Conjunctival cytology.

H. ROMMEL HILDRETH: Surgical anatomy of the eye and orbit.

GEORGE H. BISHOP and B. HOWARD BARTLEY: Physiology of the eye.

PERCY W. COBB: Physiological optics.

CHARLOTTE WEIGHARD: Chemistry relating to ophthalmology.

ROSALEANE A. HETLER: Nutrition relating to ophthalmology.

LOUIS A. JULIANELLE, CHARLES WEISS and MARION C. MORRIS: Bacteriology of the eye.

R. WENDELL HARRISON: Tissue culture of the eye.

Staff—Daily, 2:00. Laboratory demonstrations. GEORGE E. HOURN, LOUIS J. BIRSNER, JAMES B. COSTEN, HARRY N. GLICK, I. D. KELLEY, JR. and DOROTHY WOLFF: Anatomy of the eye.

W. F. Wenner and P. R. Nemours: Physiology of the eye.
Catherine Buhrmester: Chemistry of the eye.
Evelyn Dixon: Bacteriology of the eye.
S. M. Dean: Cytology.
A. J. Cone: Temperature changes.
Louis K. Guggenheim: Embryology.
Arthur W. Proetz: Sinus study.
B. J. McMahon and Clifford Menzies: Pathology of the eye.

Harvey J. Howard—Thursday, 2:00. Staff conference.

Central Institute for the Deaf

Monday

F. K. Hansel—2. Allergic clinic.
C. C. Bunch—2. Hearing tests.
H. N. Glick, Helen Gage, Allen Potter, L. C. Boemer and George Saunders—3. Otolaryngological diagnostic clinic.
A. W. Proetz—4. Demonstration of cases.

Tuesday

Staff Conference—9.
F. K. Hansel—2. Allergic clinic.
C. C. Bunch—2. Hearing tests.
H. N. Glick, Helen Gage, Allen Potter, L. C. Boemer and George Saunders—3. Otolaryngological diagnostic clinic.
I. Y. Olch and Clifford Menzies—4. Demonstration of cases.

Wednesday

Staff Conference—9.
F. K. Hansel—2. Allergic clinic.
C. C. Bunch—2. Hearing tests.
H. N. Glick, Helen Gage, Allen Potter, L. C. Boemer and George Saunders—3. Otolaryngological diagnostic clinic.
L. K. Guggenheim and Dorothy Wolff—4. Demonstration of cases.

Thursday

Staff Conference—9.
F. K. Hansel—2. Allergic clinic.
C. C. Bunch—2. Hearing tests.
H. N. Glick, Helen Gage, Allen Potter, L. C. Boemer and George Saunders—3. Otolaryngological diagnostic clinic.
W. F. Wenner and P. R. Nemours—4. Demonstration of cases.

Friday

F. K. Hansel—2. Allergic clinic.
C. C. Bunch—2. Hearing tests.
H. N. Glick, Helen Gage, Allen Potter, L. C. Boemer and George Saunders—3. Otolaryngological diagnostic clinic.
Evelyn Dixon and Catherine Buhrmester—4. Demonstration of cases.

Children's Hospital

Tuesday

H. W. Lyman, I. D. Kelley, Jr. and L. E. Freimuth—11. Otolaryngological operations.

Friday

G. E. Hourn and A. M. Alden—9. Otolaryngological operations.

ST. LOUIS UNIVERSITY

St. Mary's Hospital

Monday

W. E. Sauer, S. B. Westlake, R. H. Milligan and C. O. Brown—2. Otolaryngological operations.
William Luedde and associates—2. Ophthalmological clinic.

Wednesday

William Luedde and associates—2. Ophthalmological clinic.

Thursday

W. E. Sauer, S. B. Westlake, R. H. Milligan and C. O. Brown—2. Otolaryngological operations.

St. John's Hospital

Tuesday

E. P. North, V. L. Jones, N. L. Donnell and John McGrath—2. Demonstration of ophthalmological cases.
C. F. Pfingsten—2. Otolaryngological operations.

Thursday

V. V. Wood—2. Demonstration of otolaryngological cases.

Friday

V. V. Wood and Elmer Schluer—9. Otolaryngological operations.

Firmin des Loges Hospital

Monday

W. H. Luedde and John Green—2. Ophthalmological operations.

Tuesday

J. F. Hardesty and M. L. Greene—2. Ophthalmological diagnostic clinic.
W. E. Sauer—2. Otolaryngological operations.

Thursday

Eugene T. Senseney—2. Otolaryngological operations.

St. Anthony's Hospital

Monday

F. G. A. Bardenheier—2. Otolaryngological operations.
J. M. Keller—2. Ophthalmological clinic, operations and demonstration of cases.

Wednesday

J. M. Keller—2. Ophthalmological clinic, operations and demonstration of cases.

Friday

F. G. Bardenheier—2. Otolaryngological operations.

Mount St. Rose Sanitarium

Wednesday

William Smit—2:30. Otolaryngological clinic.

Friday

William Smit—2:30. Otolaryngological clinic.

ALEXIAN BROTHERS HOSPITAL

Monday

J. M. KELLER—3. Ophthalmological clinic.

Tuesday

D. P. FERRIS—2. Otolaryngological clinic.

Wednesday

J. M. KELLER—3. Ophthalmological clinic.

Thursday

D. P. FERRIS—2. Otolaryngological clinic.

ST. LOUIS COUNTY HOSPITAL

Monday

O. W. KOCH, J. B. COSTEN and A. M. ALDEN—2. Otolaryngological operations.

Wednesday

C. P. DYER, WILLIAM F. HARDY and JOHN MCGRATH—2. Ophthalmological operations and demonstration of cases.

Friday

JOHN GREEN and CARL BEISBARTH—2. Ophthalmological operations.

ST. LOUIS CITY HOSPITAL

Tuesday

CARL EBER—2. Ophthalmological operations.
E. LEE MYER—2. Otolaryngological operations.

Friday

E. LEE MYER—2. Otolaryngological operations.

MISSOURI BAPTIST HOSPITAL

Monday

R. J. PAYNE—2. Otolaryngological operations.
H. N. GLICK—2. Otolaryngological operations.

Wednesday

R. J. PAYNE—2. Otolaryngological operations.
H. N. GLICK—2. Otolaryngological operations.
J. F. HARDESTY—2. Ophthalmological operations.

DEACONESS HOSPITAL

Monday

V. V. WOOD—2. Otolaryngological clinic.
F. C. SIMON—2. Otolaryngological operations.

Wednesday

V. V. WOOD—2. Otolaryngological clinic.
F. C. SIMON—2. Otolaryngological operations.

DEPAUL HOSPITAL

Tuesday

V. V. WOOD—2. Otolaryngological operations.

JEWISH HOSPITAL

Monday

EUGENE T. SENSENEY—2. Radical mastoidectomy.
I. D. KELLEY, JR.—2. Direct vision adenectomy.
A. M. ALDEN—2. Classic closure of mastoid fistula.

Tuesday

MAX W. JACOBS and B. Y. ALVIS—2. Ophthalmological clinic, operations and demonstration of cases.

Wednesday

E. LEE MYERS and staff—2. Demonstration of bronchoscopy cases; laryngectomy.
C. E. EIMER—2. Direct laryngoscopy examination (Haslinger).
I. D. KELLEY, JR.—2. Lynch suspension.
M. D. PELZ, O. R. DOBBS and MAXWELL FINEBERG—2. Diagnostic clinic with demonstration of cases.

Thursday

MEYER WIENER—2. Ophthalmological operations.

Friday

LOUIS K. GUGGENHEIM—2. Demonstration of cases.
A. M. ALDEN—2. Snare and guillotine tonsillectomy and demonstration of ligation of bleeder; dacryorhinocystotomy.
S. B. WESTLAKE—2. Radical mastoidectomy.

LUTHERAN HOSPITAL

Tuesday

F. C. SIMON—2. Otolaryngological operations.

Thursday

F. C. SIMON—2. Otolaryngological operations.

MISSOURI PACIFIC HOSPITAL

Tuesday

S. B. WESTLAKE—2. Otolaryngological clinic.

Wednesday

E. P. NORRIS and VINCENT JONES—2. Ophthalmology, diagnostic and operative clinic.

ST. LUKE'S HOSPITAL

Monday

W. E. SHAHAN—2. Ophthalmological operations.

Tuesday

B. J. MCMAHON—2. Otolaryngological operations.

Thursday

B. J. MCMAHON—2. Otolaryngological diagnostic clinic.

FRISCO EMPLOYES' HOSPITAL

Tuesday

RICHARD J. PAYNE—2. Pulmonary lavage.

Wednesday

J. ELLIS JENNINGS—3. Tests for color blindness.